THE INTELLECTUAL OBSERVER.

FEBRUARY, 1866.

LIFE AND DEATH IN OUR MINES.

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WHO among us, on taking up a newspaper on the morning of the 23rd of December, 1865, could read the harrowing and heartrending details of the colliery explosion at Merthyr Tydvil without a shudder, and a regret that as yet, with all the increasing scientific knowledge of the day, no remedy had been suggested, no means taken to effectually guard against results of fire-damp in mines? Thirty-four human beings killed, and nearly as many more injured, in this one fatal explosion. It would be well if such calamitous incidents secured the attention of the public to the deplorable fact that the sacrifice of the very large number of 1644 human beings, in the full enjoyment of life, is called for annually in our coal-mines, and arises, as I shall presently show, in the generality of cases, *from preventible causes*, and of these no less than 365, or one per diem, is offered up to that dread spirit of destruction, *fire-damp;* for it has been positively determined by Mr. Holland that the deaths from this deleterious gas alone average one for each day in the year.

The census of 1861 gave 282,474 males as employed in coal-mines; of these, one in 355 annually meets with death by accident of some sort; and during the year 1864, one life was lost in raising every 109,715 tons of coal from the pit. It is true that coal must be had, or the industry of this nation would soon be paralyzed; but must we necessarily pay for it by the annual sacrifice of 1644 hale and hearty fellows? Has science no remedy to offer us that shall be effective in warding off a spirit of evil so dreaded as either fire or choke-damp? This is, indeed, both a serious and momentous question. Before an answer is attempted, we must not lose sight of this important fact, that as long as miners are obliged to employ a lamp, or use a flame of any kind, to illuminate the dark cavern in which they work, surrounded by a dangerous and ever-accumulating gas, which may at any moment be ignited and exploded, so long will they be exposed and subjected to the fearful horrors attending an explosion; and as long as there is "*fire-damp*

below," is there a risk that some one act of stupidity or carelessness on the part of a miner will occasion a wholesale slaughter, of it may be some hundreds, of human beings; and so long will the public mind be periodically shocked by the ever-recurring announcement of *"Another colliery explosion, with fearful loss of life, in the 'Reckless' mine."*

One morning, a year or two ago, we were shocked by reading of the Risca explosion, with the loss of 145 lives at one fell swoop. A still shorter time back, in the model Tredegar mine, noted for the careful management displayed in its working, "a long, rumbling sound" told of twenty-six blackened corpses lying in a heap, and many more half dead, awaiting some daring spirit to save them from the twin destroyer, *choke-damp*. It subsequently appeared that the colliery had been carefully examined only that very morning, and the ordinary means taken to test the presence of fire-damp; some of the inflammable air was found in a "cross-heading in the back-workings," but as there was no great quantity detected, the *"fireman"* thought it a sufficient precaution to put up a *"danger signal,"* whatever that may mean; which it appears was so little regarded that the men quickly followed to their usual work with naked lights. This seems to have been ordinarily permitted even in this model mine; so little are the workmen dismayed by a *"danger signal,"* or rather, so much accustomed are they to the dangers of their daily employment that they become heedless of them; and so, somehow or other, *"the gas was fired."*

If the officials in charge of the mine care so little for the results as to leave all to blind chance, or next to it, since they consider their duty done after having hoisted a *"danger signal,"* is it to be wondered at that the more ignorant workmen should err on the same side, and blindly walk into the very jaws of death, with an open lamp to light them on their way? Be it remembered, also, that miners are fatalists of the worst kind, implicitly believing that they will not die until their time comes, and that when it does, die they must; and hence they run most foolhardy risks. This very belief, however, makes them courageous even to a fault, for they will face danger most unflinchingly in endeavouring to save fellow-workmen requiring help. And so, with but few exceptions, in a more or less culpable degree, carelessness is at the root of all the sad and terrible disasters attendant upon the firing of a pit.

It must not, however, be supposed that, in the enumeration of losses of life by *fire-damp*, that we fully realize the extent of the evil going on year by year, and, I fear it must be said, in an increasing ratio. The gross total of actual deaths (on the spot) from accidents in and about the coal-mines of Great

Britain in 1864 was 777, being an increase of 20 over the deaths from the same causes in 1863. The following tabular arrangement exhibits at a glance the every-day dangers of miners:—

DEATHS IN 1864. IN THE SHAFT.

From overwinding; that is, when the engine is not stopped in time, and the tub is drawn over the pulley, and the miners are thrown bodily down the shaft	5
From falling, either from the surface, or from part of the way down the shaft, *e.g.*, as where the same shaft works two seams of coal	36
From breaking of ropes or chains; that is, the ropes or chains which raise and lower the tubs, cages, etc.	9
From accidents while ascending or descending, such as from falling off the tub or cage, or being struck by the return tub	32
From miscellaneous accidents in shaft; such as the catch breaking or being stuck fast, or allowing the tub or cage to go down into the "sump" (a water cistern at the bottom of the shaft)	36
From things falling down the shaft	25
From things falling from part of the way down; as from the side of the shaft, etc.	15
	158

IN THE PIT.

From explosions of fire-damp	59

We must not omit to mention that deaths resulting from explosions after removal from the pit are not included in these 59. Thus, in 1860 there were 4 deaths from explosion, but 26 other deaths resulted, making actually 30, yet only the 4 were estimated. It has been positively ascertained by Mr. Holland, one of the Royal Commissioners of Mines, that there is one life lost every day throughout the year from explosions alone.

From falls of coal; that is, falls of detached masses of coal which are imperfectly propped, or which fall before expected	118
From falls of roof; that is, falls of stone from the roof or sides of the galleries. These arise from the fact, that the weight of the earth pressing on the pillars left to support the roof sinks them down into the earth, or, as the miners say, "raises the floor," and, in consequence, large masses of stone become detached, and fall unexpectedly	262

From explosions of gunpowder; that is, gunpowder used for blasting coal, or in making a new roadway in the pit, or raising the roof, etc.	15
From miscellaneous accidents; that is, suffocation, irruptions of gases or of water, falls into water, on the inclined plane, etc.	102
	556

On the Surface.

By machinery	14
By bursting of boilers	3
By miscellaneous accidents	46
	63

Total Number of Deaths—

In the Shaft . .	158	
In the Pit . .	556	
On the Surface .	63	
	777	actually killed on the spot; but
	867	there were other 867 deaths re-
		sulting from accident, making
	1644	1644 actual deaths from accidental causes.

We cannot altogether overlook or entirely ignore another source of danger to life in mines—one greatly affecting health and shortening life, and thereby increasing what is commonly, but wrongly, spoken of as the *natural death ratio of miners*—namely, the imperfect ventilation of mines. In our northern coal-pits as much care is taken as can be got out of an imperfect system to maintain an interchange of pure air; but in most metal mines this great necessity of life is shamefully and systematically neglected. An eye-witness graphically describes the present condition of a Cornish mine:—

"The only air-engine found working in one big mine was a piston in a rough deal box; a panting short-armed little boy pulled and pushed at the cross handle. The air was close where he worked, and the squirt and its pipes leaked. A long way off, at the 'end,' a very faint puff, which gently bent the flame of a candle for a moment, was the sole result of each violent effort. . . . . Men at work in bad places pant and seem to breathe painfully. Their faces are red or purple; their veins swelled; their brows wet, and begrimed with soot. They seem to labour hard, though their work is not harder than quarrying stones elsewhere. In such places candles flicker

and sometimes go out altogether; no puffing or drawing will light a pipe or keep it lighted. There is no laughter, no fun; no busy cheering chatter of active labour; all is silent toil; the carbonic acid is not laughing gas. . . . .

"The death-rates per 1000 between certain ages are as follows:—

Ages.	Cornish people above ground.	Northern colliers.	Cornish men under ground.
35 to 45	10	10	14
45 to 55	15	17	34
55 to 65	24	24	63 " *

Is such a lamentable death-rate to be longer permitted to pass unheeded?

Now comes the important question, What has science done to ameliorate this long list of dangers to the miner? But before we enter upon the consideration of this question, it will be necessary to comprehend quite clearly the *nature and properties of fire-damp.*

First, the gas is light, and therefore rises to the upper part of a gallery in a mine, and remains in that position, unless in exceptional cases. It is inflammable, burning with a luminous flame, and in its combustion forming water and carbonic acid, the latter being the "choke-damp" of the miner. A mixture of fire-damp and air, containing six per cent. of the gas, burns quietly; if the quantity of the combustible element be increased to seven per cent., the mixture explodes feebly; the most destructive explosion taking place when ten and a half parts of fire-damp are mixed with eighty-nine and a half of air. Fire-damp, fortunately, requires a high temperature to ignite it, and by its combustion produces a still higher one; consequently it singes off the hair, burns the skin, sets fire to garments, and at times even sets fire to coal; hence we occasionally hear of mines being on fire. The gas has a peculiar odour, which, however, varies considerably; in some mines it has a faint smell of alcohol, in others of tar, and again in others it has a fœtid odour not unlike fennel. For experimental use it is readily procurable, being eliminated when a mixture of equal parts of acetate of potash, caustic potash, and quick lime is strongly heated. It occurs naturally as a result of the decomposition of vegetable matter contained in the mud

* J. F. Campbell's *Frost and Fire*, vol. i., page 55.

of stagnant water, such as rivers, ponds, marshes, etc.; hence its name marsh-gas.

A common cause of explosions, not often explained or even thought of, may be found in the variations of the pressure of the atmosphere, as indicated by the barometer. The gas having collected in a "Goaf," is retained there by the high pressure indicated by the barometer—suddenly the barometer falls, the mass of gas expands, and some unfortunate workman, not knowing what has happened, walks into the danger with a naked light, thereby exploding it may be acres of gas.

Until the beginning of the present century, the only means of ascertaining the accumulation of fire-damp to a dangerous extent was at the almost certain risk of igniting the whole; while the dim light afforded by the *steel-mill* was the only one with which a dangerous atmosphere could be approached; and even with this, there was the actual danger of the sparks given off inflaming the gas. In 1812, the insufficiency of the then existing arrangements was made painfully apparent by the Felling Colliery explosion; the fact of a pit judiciously worked, and, as was supposed, adequately ventilated, being subjected to so extensive a calamity as to cause the loss of three-fourths of the large staff of workmen employed in it, led many to make the most earnest endeavours to devise some remedy for the evil. The first recorded invention in this direction was a lamp devised by Dr. Clanny, said to be capable of being burnt in an explosive atmosphere: this consisted of an arrangement for blowing the air to support combustion through a column of water, and for permitting the escape of the heated air through the same medium. Sir Humphrey Davy then turned his attention to the subject, and found, while pursuing his remarkable "researches on flame," which afterwards led to the invention of the *Safety Lamp*, that no explosion could be produced in a mixture of air and fire-damp passing through a narrow tube, owing to the cooling influence exerted by the tube upon the gas, and that the narrower the tube, the shorter was the length required to produce this protective effect.

Flame is well understood to be, in all ordinary cases, a luminous envelope, which forms a limiting surface between the unburned combustible within and the supporter of combustion without. Hemming's safety tube for the oxyhydrogen blowpipe depends for its efficacy upon the cooling influence which the metallic tubes or channels exert upon the burning jet. The heat of the flame is in this way prevented from passing backwards, and causing the explosion of the mixed gases in the reservoir.

It is well-known in the laboratory, that, by using wire gauze, we may easily cut off the upper part of a flame, the

unburned gases being reduced in temperature below the point required for ignition; and if we employ a piece of gauze with about 400 meshes to the square inch, the conducting power of the metal is sufficient to cool the flame below the point of ignition, even though the wire itself may become red-hot. In a similar manner the gas above the gauze may be kindled, and the flame will not pass through to that below.

Sir H. Davy, in the construction of his miner's lamp, beautifully adapted these principles, so that the miner might carry on his work without allowing the flame to come in contact with the surrounding atmosphere. The wire gauze used in the construction of these lamps contains from 700 to 800 meshes in the square inch. In a strong current of air, the heated gas may be blown through even this fine gauze before its temperature is sufficiently lowered to prevent an explosion; but, of course, such an occurrence might be easily guarded against. The lamp itself is merely an ordinary oil lamp, inclosed within a cylinder of this fine wire gauze; it is provided with a double top, and a crooked wire, which passes up tightly through a tube traversing the body of the lamp, for the purpose of trimming the wick without the necessity of removing the wire case. When such a lamp is introduced into an explosive mixture, the flame is seen gradually to enlarge as the proportion of the gas increases, until at length it fills the entire gauze cylinder; when the gas is greatly in excess, the lamp is entirely extinguished; if it be withdrawn from the mixture while the cylinder appears full of flame, the wick is rekindled. Whenever this pale, enlarged flame is seen, the miner should withdraw; for although no explosion may be looked for while the gauze is sound, yet at a high temperature the metal rapidly oxidizes, and then easily breaks into holes. In such a case, a single aperture of sufficient size determines a fatal explosion.

The means employed for detecting *fire-damp* are few and simple. The viewer or his deputy inspects all the working places in a coal-mine before the men are allowed to begin work, and with his Davy lamp determines whether it is safe for the men to use naked lights, or whether they are to employ the safety lamp. In the latter case, the lamps are securely locked; but even then the men will at times suck the flame through the wire gauze to light their pipes, and by this selfish act they hazard their own lives, as well as that of their fellow-workmen.

In the viewer's trial, he reduces the flame of his lamp to about the size of a horse-bean, and then slowly raises it into the suspected atmosphere, carefully watching the flame. If there be three per cent., a pale blue cap overhangs the flame;

if more than five, but less than seven per cent., the flame elongates in proportion to the quantity; if more than seven, but less than fifteen per cent., the lamp explodes (that is, the gas within the gauze) with less or greater violence; if the mixture contains more than fifteen or sixteen per cent. of fire-damp, it burns quietly; and if more than this, it is unable to support combustion, and the lamp is extinguished. In former times these trials were made with a naked candle, and an explosion commonly told of the presence of the gas: and even with the Davy lamp in competent hands, these trials are not actually safe, as is evidenced by the report lately made by Mr. J. J. Atkinson, Inspector of Mines in the Durham district, wherein he gives in detail two instances of explosions through the gauze of Davy lamps, which were found still in a perfect condition even after the explosions.

One of these explosions took place at Newbottle colliery, "through two workmen unexpectedly opening a communication between the Margaret pit and the Jane pit workings at that colliery, on the 8th of April, 1864, the latter pit having been abandoned for about sixty years, and the shaft closed up, after an explosion. On opening the communication, gas came out of the old workings with considerable force, and the workmen ran away, leaving their safety lamps behind. Very soon a slight explosion took place, and the coal was set on fire, and that part of the workings had to be closed off for some time, in order to extinguish the fire. When the fire was extinguished, and the place was again reached, strange to relate, both safety lamps were found to be in good order. They were common Davy lamps." It appears that there are also precautions required before using a new Davy lamp. The wire, at the time of its being drawn out, is lubricated with oil, to enable it to pass through the steel die that regulates its size, and it is found that it retains on its surface a thin film of this oil, even after it has been woven into gauze, If, therefore, a new lamp be taken into an explosive mixture, the ignition and combustion of that mixture heats the gauze to redness, and the oil volatalises, and ignites the fire-damp outside the lamp. These, and other important facts, have recently received the fullest investigation at the hands of Mr. Atkinson, who, we hope, will collect them into a paper, and publish the same for the benefit of mankind.

To fully comprehend, then, the advantages and disadvantages of the Davy lamp, we will take them *seriatim:*

1st. The fire-damp will explode through the gauze of a perfectly constructed lamp.

2nd. The lamp goes out if taken into a very impure atmosphere, and this happens in cases where light is absolutely

necessary to the saving of life, or where there are urgent works to be conducted in an atmosphere which will support life for a short time, but where the Davy lamp will not burn. On this ground it is to be hoped that a means will be found of using the electric light in some way or other, either in Dumas' form, or in that of the diver's lamp.

3rd. The Davy lamp may be, and indeed, as we have already seen, often is, opened by the miner, even after it has been locked by the viewer, either to light his pipe, or to obtain more light, for the gauze sadly obstructs light.

4th. It may easily be extinguished by a current of air, or by a drop of water falling from the roof of the gallery.

5th. If the lamp be tilted on one side the oil is liable to run over the gauze; and in such a case, as not unfrequently happens, it causes an explosion.

We must not, however, lose sight of the fact, that in spite of the disadvantages just enumerated, the Davy lamp has proved of very great value to the miner. First, in the detection of fire-damp in pits, and then in giving sufficient light for the miner to work in an atmosphere containing a considerable amount of an explosive gas. Many changes and alterations have been from time to time proposed for the purpose of overcoming some of the objections above mentioned, but hitherto all the proposed fancied improvements have ended in disappointment and vexatious failure. A somewhat more important lamp is offered in Dumas' electric light for the purpose of working mines with safety. This lamp consists of an induction coil, enclosed in a box, with a tube of uranium glass about a foot long in the front. The positive and negative platinum points are introduced, one at one end, and the other at the other, a vacuum is then produced in the tube; by turning a small screw the current passes from point to point, and produces the well-known electric light. The light is much inferior to that of the Davy lamp; indeed, it is only just sufficient to enable the miners to grope their way about. The whole affair is unfortunately cumbrous and expensive (costing about £10), and therefore not likely to be brought into general use, at least in its present form. Danger is, however, reduced to a minimum, because in the event of fracture of the glass tube, the vacuum is destroyed, the air rushes in, and the lamp is immediately extinguished.

We may then conclude that all mere mechanical contrivances for shutting off the gas from the source of illumination have proved failures, and altogether inadequate to grapple with the difficulties to be dealt with in mines; and therefore science has been driven to look in another direction for the means of lessening the dangers attendant upon mining. Mr. George F. Ansell, of the Royal Mint, lately invented a most

delicately sensitive "Indicator," whereby he is able to detect the smallest appreciable quantity of fire-damp in a mine. This is undoubtedly a step in the right direction.

As in the case of the safety lamp, Ansell's Fire-damp Indicator is the practical application of a natural law, that of DIFFUSION. Dr. Priestley first noticed the phenomenon which has since been more fully developed by Berthollet and Dobereiner in 1825, and by Graham still more recently, who evidently sought out and explained the law which governs the diffusion of gases, and which law may be thus popularly explained:—When two different gases, as atmospheric air and fire-damp, for example, are brought into contact with each other, they have a tendency to mix; and whilst this mixing is taking place, the atoms of each gas travel at a certain speed peculiar to that gas, which speed remains the same under all circumstances. Another peculiarity is, that the speed of a gas remains the same whether it is passing into space or intermixing with another gas, and whether it is passing through a porous substance or an open tube. Mr. Ansell practically applies these facts to the detection of fire-damp; and since his indicator enables him to ascertain the exact percentage of this or other deleterious gases, the application is of the very highest importance and value, not only for coal and metal mines, but wherever subterranean works of any kind have to be carried on, for it readily indicates the presence of the deadly choke-damp, if in any poisonous amount. It is also capable of being made equally useful for the detection of coal-gas in houses and large buildings, as theatres, railway tunnels, and the proposed subways in our streets; or in the holds of ships, where foul air or fire-damp often collects. It may be stated, *en passant*, that a short time since the newspapers gave an account of one ship lying at Liverpool, and another at Sunderland, having suffered great damage, attended with loss of life, by the explosion of an unsuspected accumulation of marsh gas in their holds. In well-sinking, and various other branches of mechanical art, it is capable of being turned to most valuable account for the preservation of human life.

Many of the phenomena attendant upon the mixing of gases are so novel and interesting, that we cannot quite pass them over without a few observations; and for the better elucidation of our subject it will be as well that we should briefly notice some of the more important. The laws which govern the movements of mixed gases are of a totally different character to those which operate upon mixed fluids. The latter are invariably arranged in strata, or layers as it were, and in exact accordance with their specific gravities, the lightest finding its way to the surface, and the heaviest sinking to the bottom of

the vessel in which they are placed. From this fact it is concluded that no chemical action is exerted in order to effect their incorporation, and that by the force of gravity alone each liquid assumes its relative position. With respect to gases, which also vary in density to a very considerable extent, no such separation takes place. If chlorine, the specific gravity of which is thirty-six times as great as that of hydrogen, be placed in one of two distant vessels, and be allowed to communicate by means of a long tube, the hydrogen, or the lighter gas, being placed uppermost, the heavier chlorine will, in the course of a few hours, find its way into the upper jar, as may be seen by its green colour, whilst the hydrogen will pass downwards into the lower jar, and ultimately the two gases will be found to be equally intermixed throughout, and when once mixed, there is no disposition to separate again, however long they may remain at rest together. The rapidity with which this *diffusion* occurs varies with the specific gravity of the gases; and, contrary to what might be generally supposed, the more widely the two gases differ in density, the more rapid is the process of intermixture. In the earliest investigations into this very interesting subject, a very simple apparatus was employed, which was nothing more than a plain cylindrical glass tube, ten or twelve inches in length, and one inch in diameter. It was closed at one end by a porous plate of plaster of Paris, graphite, or any dry porous substance, and was then termed a *Diffusiometer*.

In the primary application of the tube it was filled with hydrogen over a mercurial trough, a sheet of gutta-percha for the moment covering the porous plate, and rendering it more slowly permeable. On the removal of the gutta-percha gaseous diffusion through the pores of the plate immediately took place, and during the process the mercury rose in the tube to a height of six or seven inches, thus showing the force with which the impenetration of the atmospheric air is effected. Mr. Ansell's ready mode of showing this is very simple, inasmuch as he demonstrates it with ordinary coal-gas. He takes a piece of glass tubing about one inch in diameter, covers one end with a piece of tile or plaster of Paris, and fills it with coal-gas. This is supported in a jar of water, when the water immediately begins to rise in the tube, and will continue to do so in opposition to gravity, until in the course of a few minutes it stands three or four inches higher inside the tube than the surface of the fluid in the outer vessel, in consequence of the coal-gas passing out through the pores of the plaster of Paris much more rapidly than air can pass in. In the case where different gases are mixed, and then introduced into the diffusion tube, each preserves the rate of diffusion peculiar to itself. If, for instance, hydrogen and carbonic

acid be mixed and placed in the diffusion tube, the hydrogen passes out with much greater rapidity than the carbonic acid, and a partial mechanical separation of two gases differing in density may thus be effected. The rate of diffusion is, as might be expected, accelerated by a rise of temperature; for by heat all gases are rendered specifically lighter.

The rapid passage of gases through the minute pores of the plates is a remarkable phenomenon, and one which is thought to fully demonstrate the molecular theory of bodies; but still more remarkable, the infinitesimal particles of gaseous bodies find their way quite as rapidly through such substances as *india-rubber*, etc., which neither microscopical nor chemical examination had heretofore shown to be porous. Upon submitting the very finest pellicle of india-rubber to the highest powers of the microscope it presents a perfectly homogeneous appearance, and no pressure, however carefully applied, will force a fluid through its minute pores; nevertheless, gases pass readily through it.

The process of *diffusion* is one which is continually going on, and playing an important part in the atmosphere which surrounds us, as well as in the various parts of nature. The beautiful and regular movements of the fluid particles which we watch with so much interest in the Vallisneria, Anacharis, etc., are doubtless a result of the law of *diffusion*. Accumulations of gases unfitted for the support of animal and vegetable life, are by its means silently and speedily dispersed: even respiration itself could not be long maintained, were it not for the process of diffusion, which rapidly displaces that which has been rendered unfit for the support of life, and at the same time draws downwards and into the lungs a fresh supply of purer, better, and specifically lighter air.

Enough has now been said to convey a clear idea of the singularly beautiful phenomenon of the diffusion of gases, and light the way to a more exact comprehension of Mr. Ansell's *fire-damp and gas indicator*.

Carburetted hydrogen, either heavy, in the form of olefiant gas, or light as marsh or coal-mine gas (in both cases lighter than air), diffuses readily through air, as we have already shown; and upon this is founded Mr. Ansell's beautiful method for detecting its presence.

It was represented to this gentleman that *fire-damp* would become comparatively harmless if its presence in a mine could be made known by a signal in the manager's room above-ground; the essential condition being, that such means should be entirely self-acting. In September, 1862, Mr. Ansell visited some coal-mines in the Midland district, for the purpose of ascertaining the conditions to be met, and was conducted to a portion of a pit known to be pretty tolerably charged with

an explosive mixture. The gas caused a peculiarly helpless feeling to come over him, and "his head had an extraordinary light feeling"—so much so, that it occurred to him, that if his head had been made of india-rubber, he could have brought away some of the gas; in his own words, "his head appeared to be filled with fire-damp." On his return home, an india-rubber balloon his child was playing with, attracted his attention, and he thought he might turn this plaything to account; this thought was elaborated, and associated with a law just spoken of, and uppermost in his mind—namely, that of osmose, or diffusion.

Before his next visit, he had not only thought out this happy idea, but had provided himself with the simple apparatus shown in Fig. 1, consisting of an india-rubber balloon, bound round the centre with a linen band, secured in the manner shown in the wood-cut, between the foot-board, F, and the moveable arm, C. By the expansion of the balloon, the arm, and a lever, D, are raised, and a spring bell, E, fixed above, liberated and set in motion.

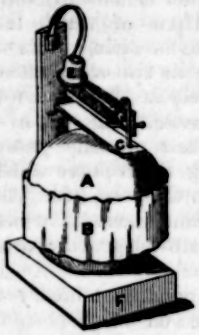


FIG: 1.

This first experiment was so near to perfection, that all subsequent improvements in the form of the apparatus partake more of the nature of scientific refinements than that of a positively necessary departure from the original conception, as may be readily seen upon comparing Fig. 1 with the latest adopted form shown in Fig. 2.

Fig. 2, *a*, is a small balloon of india-rubber, filled with atmospheric air, bound round the middle with a band of linen, to prevent lateral expansion. This is placed under the lever, *b*, resting on a stand, F, where there is a screw to adjust the bag of air to a proper height. When adjusted, the balloon presses lightly upon the lever, *b*. If this arrangement be placed in an atmosphere containing but a small percentage of carburetted hydrogen, this gas passes through the india-rubber by diffusion, and, of course, expands the balloon. In expanding this the lever is raised; and by the arrangement shown at *c*, the ratchet wheel is released, and the cord and weight, *d*, liberated; and by the fall of the latter down the pillar, a bell is rapidly and re-

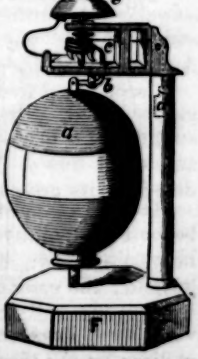


FIG: 2.

peatedly rung. By the same forms of apparatus connection may be made and broken with a voltaic battery, or a magneto-electric machine put in motion, and a telegraphic signal given at the surface of the mine, either in the office or in any convenient place.

Fig. 3 is another form of instrument. A U-shaped tube, longer in one arm than in the other, and having the short arm provided with a bulb, is passed through the bottom of a porous battery cell, and cemented securely; then the open end of the cell is closed by a disk of wood, and cemented on by sealing-wax. The tube is partially filled with mercury, on the surface of which is a floating weight attached to a string, this is carried over a pulley, and by its rise or fall moves an index upon a dial, precisely in the same way as an ordinary wheel barometer. The gas, even when it exists in the smallest quantity, passes into the porous cell, and thus increasing the volume of the enclosed air, it presses the mercury up into the tube, lifting the float, and moving the index. This arrangement may also be used to ring a bell, or to establish electro-telegraphic communication.

FIG: 3.

Fig. 4 is a glass U-tube, containing a little mercury or coloured water. This is fixed upon a board on which is a scale graduated by experiment. Over one arm of the tube is fixed a porous plate. This is then carried into the colliery, and the percentage of gas in the air is shown by the rise of the fluid in the open arm of the tube.

FIG: 4.

Fig. 5 consists of, A, a porous tile, secured into a glass vessel, B, which is connected with a U-tube, having some mercury in it. The arrangement is then made as in the former case, so that the index is moved the moment diffusion takes place.

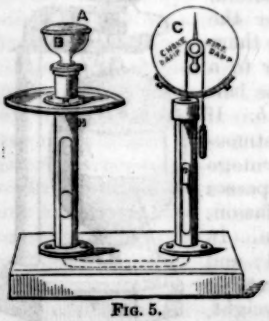


FIG. 5.

There are many other forms which might be given to this apparatus. Indeed, Mr. Ansell has completed one of a most portable description, which is about the size of an old-fashioned watch. It can, therefore, be carried into the colliery by the viewer, in his pocket, and employed at any moment to determine the amount of dangerous gas present in the air.

When diffusion has been completed, that is, when the air within and without the porous septum has become of the same character, the index retires to zero, and remains at that point until there is a change in the mixed airs or gases; but if then the air be purified, the index travels back from zero, showing purification. To restore the instrument to its normal condition, so that it will be ready for use in *any* atmosphere, nothing more is necessary than to place it for a few minutes in an atmosphere which is free from carburetted hydrogen.

If it be desired to give instant notice to the men at work, or to the people above ground from the working places, he uses a porous battery cell, which, with a small column of mercury, gives warning in a few seconds of a sudden irruption of fire-damp. The action of the instrument is so immediate, that, unless seen, it would appear to be incredible; it is, nevertheless, trustworthy and certain. Supposing the atmosphere which has caused the indication to remain unaltered, then the instrument empties itself by effusion, and the indicator returns to the original zero, and remains at that point until the mine is ventilated, when the indicator retires from zero, thus indicating the purification of the dangerous place. These remarks also apply to the pocket aneroid about to be explained.

The instruments above spoken of are intended to give warning alone; but if it be desired for the information of viewers, inspectors, owners, and others, to ascertain the amount per cent. of fire-damp present in the air of mines, Mr. Ansell varies the form of his apparatus, the most convenient form for that purpose being that of a small aneroid barometer for the waistcoat pocket. The mercurial barometer, when fitted with the necessary accompaniments, affords very satisfactory results, as also does a column of mercury not representing a barometer. As regards the aneroid barometer, he removes the brass back, and replaces it by a piece of porous tile, the ordinary biscuit-ware of Wedgewood. The instrument so completed, with a few additional and simple mechanical arrangements, may be used as an ordinary aneroid barometer; but at the time of using it, to tell the amount of fire-damp present, it is necessary to close the valve by a small screw. Then having read the point at which the barometer stands, and noting this as the zero, remove a brass cap which protects the porous tile, and if there be any fire-damp present, the hand travels over the face of the dial, because the diffusion of the fire-damp into the chamber of the aneroid barometer causes an increased volume, which, being obliged to occupy a fixed space, makes pressure on the partly exhausted chamber within that space, and thus causes the hand to move over the face of the dial, indicating unfailingly the amount per cent. of explosive gas. In round numbers, 1 per

cent. of gas is equal to ·01 inch, and 10 per cent. of gas to ·10 inch on the aneroid barometer. The following results have been obtained in the presence of experienced miners by the Aneroid Indicator:—

The aneroid indicated 1·5 per cent. of fire-damp. The Davy lamp gave no indication.

The aneroid indicated 3·0 per cent. of fire-damp. The gas could be detected by the Davy lamp, which gave a small pale blue cap of flame.

The aneroid indicated 6·0 per cent. The Davy lamp did not explode, but its flame elongated greatly.

The aneroid indicated 8·0 per cent. The Davy lamp exploded feebly.

The aneroid indicated 10·0 per cent. The Davy lamp exploded fiercely.

In the words of a competent critic, "It is impossible to conceive a more refined application of science than this, nor one that will be found of greater practical utility, as indicating the presence of fire-damp in collieries, before it becomes dangerous from accumulation."

A few last words as to the grave responsibility which attaches to mine owners. That coal owners should hesitate, or decline to employ, Ansell's Fire-damp Indicator, seems to arise either from gross ignorance, or a sordid desire to secure the economical working of their mines, regardless of the lives and health of those employed within them. It appears to me that every instance of a frightful rate of mortality, such as we have seen associated with mining, is a just subject for legislative interference. Whenever evidence is adduced that the death-rate among workpeople engaged in any employment habitually exceeds a certain maximum, which the legislature would have no real difficulty in fixing, I think it only reasonable to demand that every such undertaking should be held illegal after fair notice and opportunity of amendment has been given. That those who derive their riches from the labour of the poor man should be compelled to use for his protection every means which science can devise, or, failing this, that they shall be held as legally responsible as railway companies are for the lives and limbs of those who suffer from their negligence.

MARINE TELEGRAPHY.

(SECOND PAPER.)

BY RICHARD BITHELL, B.SC., PH.D.

IN reading the narrative of the late attempt to lay the Atlantic cable, we met with such phrases as the following:—

"The insulation tests showed a high degree of excellence, 150,000,000 units."

"The insulation is increasing."

"Tested for conductivity, and found it perfect."

"The index light of the mirror galvanometer, which for some time had been perfectly steady, was suddenly affected by aberrations, thus showing some cause of disturbance in the current."

"The fault was *localized* within half a mile."

The first impression produced by these telegrams on the minds of a great number of men, by no means wanting in intelligence, was, that electrical science in the middle of the Atlantic was a very different thing from electrical science in the laboratory, and inquiries were heard in all directions, "How is this testing effected?" "What is a mirror galvanometer? have you ever seen one?" "And the localization of a fault! Is it possible, then, to tell, when on land, or aboard ship, how far off a fault may be, even when buried fathoms deep below the surface of the ocean?" "*Dead earth*, too! what is that?"

Now, it must be conceded at once that interrogations of this sort were not at all surprising, for practical electricians have had so many difficulties to contend with, difficulties which a newspaper reporter, or "our own correspondent," could of course solve with a wave of his omnipotent pen, but which so fully engross the attention of the truly scientific workman, and which beget in him so much diffidence that he rarely turns aside to talk much about what he is doing, for two very obvious reasons, first, that he hasn't time, and secondly, that he fears he may have to unsay one week what he has said but a week before; and hence it is that he makes an immense amount of real progress long before the public know that he is doing anything at all. And when he does begin to speak he appears to have acquired a new language wherewith to describe the phenomena with which he has become acquainted, and which to the uninitiated appears almost an unknown tongue. The only thing, therefore, left for us, the public, to do under the circumstances, is patiently to inquire and learn.

As the conductivity of a line, or cable, is the first indispensable property, without which all others are useless, it will occasion no surprise that so much pains were taken to ascertain the conducting power of the Atlantic cable during its submersion, and that tests were applied with such frequency in order to determine whether it was impaired or improved.

And now, at the onset, it is well to recal to our minds the fact that all conducting substances are not equally good. Just as "the best of men are but men at best," so the best of conductors are but imperfect ones after all; that is to say, if a given amount of electric force be made to enter a wire at one end, only a part of it will reach the other end, owing to the obstruction or *resistance* it meets with in the material of the conductor, the remaining portion of the electric force having been absorbed in overcoming the resistance thus opposed to it. Those substances which offer least resistance are called the best conductors, those which offer most resistance are called the worst conductors. If the resistance thus presented by any substance be very great, such a substance is called an insulator; but as this resistance is never so great as to entirely prevent the escape of any of the electric force, it follows that we have *no perfect insulators*, as well as *no perfect conductors*.

It follows, also, that the distinction between the two is one of degree rather than of kind, and that the instruments which serve to test the efficiency of the one, will also serve for the other.

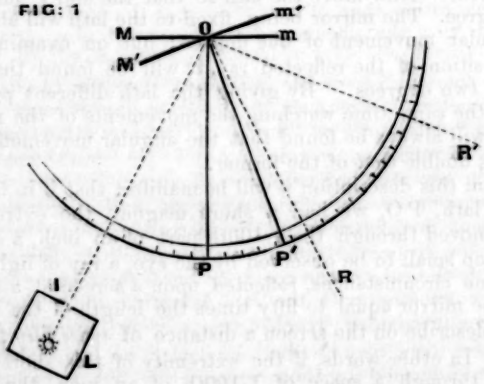
The one indispensable instrument used for testing is the galvanometer. Whatever form or name it may assume, whether "detector," or "test-box," or any other name convenient to workmen, in principle it is the galvanometer that gives the essential indications in all cases.

Galvanometors are of various forms, and of various names. All recent modifications of the instrument have been made with a view to greater delicacy and sensibility. This was pre-eminently the case in the construction of the testing apparatus used in connection with the late Atlantic cable. For reasons easily comprehended by electricians, it was decided to work this line with a very low battery power, so low, indeed, that, as I am informed by those engaged in the expedition, the testing apparatus used on the ordinary terrestrial lines would not show the faintest indication of a current through the conducting wire. Hence arose the necessity for that instrument of which we have lately heard so much, but of which we have seen so little, the *mirror galvanometer*.

The necessity for this instrument arose out of the following circumstances. The ordinary galvanometer consists, as is well known, of a small magnetic needle, which is acted upon by the coils

of an insulated wire, through which the voltaic current is passing. When such a current is strong, the needle moves with great freedom and readiness, and in the infancy of the science showed with sufficient accuracy the amount of electro-motive force given out by a battery. But when instruments were required which should indicate and measure the *faintest* currents that traversed a line, these magnetic needles were made smaller and smaller, in order to diminish their weight, until they were made too small to admit of their movements being distinctly seen. An angular deflection of one degree on such a needle was scarcely discernible by the eye, and yet this was an amount many times greater than what it was desirable to have the means of detecting. In this emergency, recourse was had to a well known law in geometrical optics, and an instrument was constructed whose index, or pointer, was a *ray of light*, a pointer that could be made of any length, and yet remain absolutely without weight. As this is one of the most simple and beautiful applications of optical science, I will give both the geometrical and experimental demonstration of the law here referred to; this will at the same time render the comprehension of the principle of the galvanometer so easy as to supersede the necessity for much further description.

FIG. 1



Let M m, Fig. 1, be a sectional plan of a small mirror, I an incident ray of light, O the point of incidence, I O P and P O R the angles of incidence and reflection respectively, P O a perpendicular to the mirror at the point O. *Then, if the mirror revolve in the plane of the angles of incidence and reflection through an angle,* M O M′ *the reflected ray,* O R, *will pass over an angular distance,* R O R′, *just double that described by the mirror itself.*

Draw P′ O perpendicular to the mirror when it has moved

through the angle M O M′. Make P′ O R′ equal to I O P, then O R′ is the new position of the ray O R.

Then, since $IOP' = IOP + POP'$

therefore its equal $P'OR' = IOP' + POP'$

By addition, $IOP' + P'OR' = 2\,IOP + 2\,POP'$

and therefore $IOR' = 2\,IOP + 2\,POP'$ (1)

But $IOP + POR = 2\,IOP$

therefore $IOR = 2\,IOP$ (2)

Subtracting (2) from (1)

$IOR' - IOR = 2\,POP'$

That is $ROR' = 2\,POP' = 2\,MOM'$.

Now, R O R′ is the angular distance over which the ray O R passes while the mirror revolves through M O M′, and is here proved equal to twice M O M′.

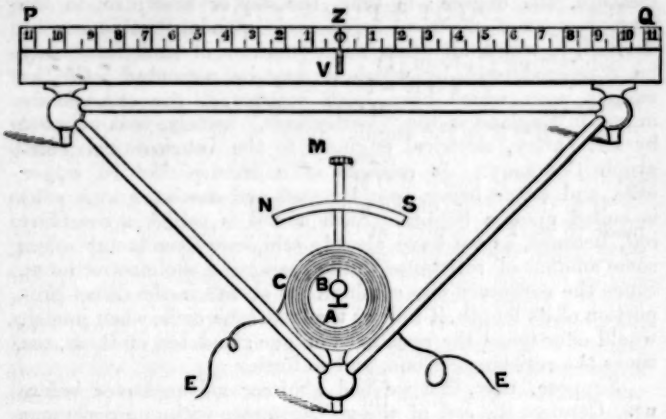
If to the bottom of the mirror a lath (P O) be fastened, and made to work on a pivot at O, and a circular scale be provided to measure the angular movement of the lath P, an experimental demonstration of the same law may be made. In the side of a lamp, L, make a fine slit, and place it so as to throw a ray of light upon O: the ray will be reflected, and will cross the scale on the opposite side of the lath, P, and at a distance equal to that at which it crossed it on its way from the lamp to the mirror. Now move the lath so that the end P shall move one degree. The mirror being fixed to the lath will also make an angular movement of one degree; but on examining the new position of the reflected ray, it will be found that it has moved two degrees. By giving the lath different positions, and at the same time watching the movements of the reflected ray, it will always be found that the angular movement of the latter is double that of the former.

From this description it will be manifest that if in the place of the lath, P O, we had a short magnet, the extremity of which moved through the 1-100th part of an inch, a quantity much too small to be observed by the eye, a ray of light under the same circumstances, reflected upon a screen at a distance from the mirror equal to fifty times the length of the magnet, would describe on the screen a distance of *twice fifty* times as great. In other words, if the extremity of this short magnet moved through a space of 1-100th of an inch, the "index light" on the screen would move *one inch*. By this contrivance, therefore, we may secure a long pointer without weight, and thus magnify a small invisible angular motion so as to render it easily discernible to the naked eye.

The way in which these principles are applied in the construction of the galvanometer is shown in Fig. 2, where C is a coil of wire, the ends of which are connected with the conducting wire, so as to form part of the circuit. In the centre

of this coil is a small magnetic needle, A, and immediately above the needle a small mirror, B. These two are fixed together, and suspended by a single fibre of unspun silk. The action of the earth's magnetism upon the needle, A, is neu-

FIG: 2



tralized by the magnet, N S, which revolves horizontally on its centre, by which arrangement the needle can be made to assume any position desired. M is a milled head, by which these motions are effected; P Q, a wooden screen, on which a scale is drawn, the zero point being at Z. Immediately under the zero is a narrow slit, V, through which the light of a lamp placed behind the screen issues, and falls on the mirror, B. This mirror is so adjusted by the action of the magnet N S upon the needle A, as that the ray which issues from the slit, and falls upon the mirror, shall be reflected back into the slit again; such adjustment being made while the apparatus is disconnected from the battery. On connecting the ends, E E, with the battery, and thus placing them "in circuit," a very faint trace of electric force in the wire will be sufficient to make the index light diverge more or less from the zero point.

We have given this minute account of the principles and construction of the reflecting galvanometer, because of its great and growing importance in connection with marine telegraphy. By its aid the insulation and conductivity of a wire are tested, and faults detected and localized; and it is even proposed to work long deep-sea cables by means of so low a battery power as to require the constant use of this

sensitive instrument in the transmission and reading-off of messages.

In all measurements it is well known to be essential that some clearly defined unit must be used, just as in estimating and recording lengths we use the foot or yard; in weights, the grain or ounce; in mechanics, the "foot-pound;" in angular measure, the degree; in time, the day or hour; so, in the measurement of electrical force some standard unit must be devised, to which all other manifestations of such force may be compared, and by which it may be measured. Of the various units which have been suggested, the one chiefly in use in England is the "Varley unit," namely, that adopted by Mr. Varley, electrical engineer to the International Telegraph Company. It consists of *a mile of No.* 16 *copper wire*, and (after being wound round and insulated with silk) is coiled upon a bobbin. Such a coil is called a *resistance coil*, because, as we have already said, every conductor offers some amount of resistance to the passage of the electric force. Since the resistance of a conductor is always in the direct proportion of its length, it follows that two such coils, when joined, would offer twice the resistance of one; and ten of them, ten times the resistance of one, and so forth.

Suppose, now, that we had a mirror galvanometer before us. Connect the coil of the galvanometer with one resistance coil, and apply a low battery power. The index light would be deflected to a certain extent, and the graduation at which it rests should be noted down. Now put two resistance coils in circuit, the battery and all other things remaining the same. The deflection of the index light will now be somewhat less, and it will rest at a point a little nearer the zero, that is the centre of the scale. Note this point also, and then apply an increasing number of coils in succession, all other things remaining as before, and we shall have a number of points on the scale noted down which correspond to a definite number of units of electrical force. But as no two batteries are exactly equal in power, and no two conductors offer precisely the same resistance mile for mile, it is necessary, when accurate measurements have to be taken, to make adjustments as here described at the commencement of every operation.

Resistance coils may be made, and are made, of wires much finer than those just named, and, if desirable, of different metals. Homogeneity of material, and fineness of the wire, are the two chief characteristics sought for in selecting the substance of which resistance coils are made. The former property tends to secure uniformity of results, the latter economises space, and diminishes the weight of the apparatus.

If, now, we suppose a battery connected with one end of a

cable as it lies coiled up inside the tank, before submersion in the ocean, and a galvanometer attached to the other end of the cable, on completing the circuit, a current of electric force would traverse the conducting wire, and cause a deflection of the magnetic needle, which deflection would be indicated by the movement of the index light along the scale. Its position should then be noted. Then, with the same battery power and galvanometer, send a current through a number of resistance coils, increasing or diminishing their number till the index light stands at the same point as when the current was sent through the cable. The number of coils so required will give the number of units of resistance presented by the conducting wire.

It will thus be seen that the conductivity of a wire is always estimated by determining the resistance it offers to the passage of the electric force, this conductivity always corresponding to the residue of such force after all resistances have been overcome, the one being inversely as the other.

If, while the cable is being submerged, similar tests be applied, the index light may be a trifle more or less distant from the zero point of the scale. If more distant it is because the residual force is greater, and causes a greater deflection of the needle; if less, because the residual force is less, and acts more feebly on the needle. Such tests may be continually applied to a cable during submersion, and if the index light under such circumstances remains steady, the inference is that the *conducting power* of the cable remains unimpaired.

The conducting power of a cable is very seriously affected by the nature of the substance used for insulation, because, as we have already said, there are no perfect insulators, any more than there are perfect conductors. For this purpose, it is well known, gutta-percha and india-rubber are universally used. Now it is recorded in the journal of the last Atlantic expedition, that the insulation of the wire actually improved after submersion in the deep sea, and it becomes a question whether this improvement arose from the action of the sea-water, or whether it was simply a result of the superincumbent pressure—a question as yet unanswered.

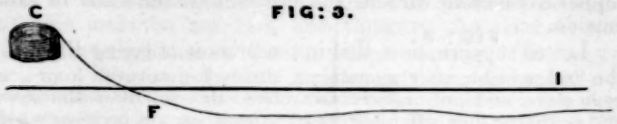
Thus far we have regarded the cable as perfect in structure. But experience shows that it is extremely difficult to make such a cable, and still more difficult to preserve one in such a state of integrity even when made. Hence arise the phenomena of "*faults.*" We shall not stop here to notice the different kinds of faults which have been distinguished and classified by electricians; the only one demanding our immediate attention is that which arises from defective insulation. Such defect may be caused by the wearing away of the outer

protective covering, or by its violent removal, or it may be caused by the intrusion of some conducting substance into the body of the cable, so as to form a communication between the copper conducting wire in the centre, and the water or earth outside.

Let us suppose, now, that in the process of laying the cable, the index light, after remaining steady for several hours, or even days, suddenly moves away from the centre of the scale, and perhaps flies off altogether. Such an occurrence would lead to a course of inferences as follows:—The movement of the light from the zero point must have been caused by the increased deflection of the galvanometer needle. This increased deflection indicates the circulation of a more rapid and powerful current through the coil, which acts on the needle; but this more powerful current could have been produced only by increasing the battery power, or by some change in the condition of the conducting wire. In the present instance we may dismiss the alternative of change of battery, as such a fact may be at once ascertained, and confine our attention to the change which has taken place in the condition of the conducting wire. The fact immediately deducible from the increased velocity and vigour of the current is, that the resistance offered by the conducting wire has been diminished; and this would happen, as it very often does on all lines, terrestrial as well as submarine, in consequence of the wearing away, or violent removal of the insulating substance with which the conducting wire is covered. A portion of a wire thus exposed constitutes a "fault." Before such a fault occurred the electric current left the ship, traversed the whole length of cable till it reached the land, and returned thence through the earth to the ship. But after the fault has occurred, the current, in virtue of its tendency always to take the shortest available course, will escape through the fault partly, but not wholly, and one portion of the current will return to the ship through the water, while the other pursues its original path along the conducting wire. Owing, however, to the large amount of conducting surface presented by the water, most of the electric force would return, and the portion of the current which traversed the wire beyond the fault would be proportionately feeble. Hence it is of the greatest importance when a fault occurs that accurate observations should be made at each end of the line, and by a careful comparison of the indications offered by the galvanometer at each end many inferences may be deduced, and the fault "localized" with more or less accuracy. Let C, Fig. 3, be the coil of cable in the ship; F, a fault in that portion of the cable which has been payed out. Let, also, the electricians on board ship transmit signals to the

shore end. They would, of course, be weak, because much of the electric force escapes, and returns to the ship. Now, let

FIG: 3.



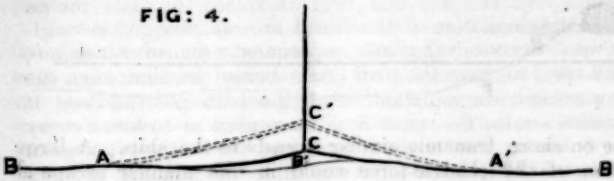
those on shore transmit similar signals to the ship. A large portion of the electric force would in like manner escape at the fault, and return to land, but the portion that traversed the wire would reach the ship, pass through the coil of cable, and move the galvanometer. Suppose that on comparing the signals on land and aboard, it is found that they are equal, and battery power and other circumstances were equal, it would be a tolerably safe conclusion that the fault lay midway between the two ends of the cable. The length of the cable being known, and the length of the portion on board being ascertainable, we have only to subtract the length on board from half the entire length, and the difference gives the distance of the fault from the ship. Unfortunately, few cases which occur in practice are so simple as this, and the reductions which are necessary in order to "localize" a fault, when the signals at each end vary in intensity, are extremely tedious and difficult.

Sometimes it happens, as in the late Atlantic expedition, that the cable parts completely, in which case it is evident no signals can be transmitted from one station to another. The current then returns wholly through the water back to the battery from whence it issued; the battery itself "works harder," to keep up a supply of force to meet the extra demand caused by the large conducting surface now open to it, and the stations at each end witnessing similar phenomena, though quite detached from each other, report "dead earth," a term long in use by land electricians, and implying simply that all the electric force transmitted by a battery returned through the earth to the station from which it was issued.

A word or two on the subject of grappling for a broken cable. "Grappling" and "hauling" are words in frequent use, and, as commonly employed, denote operations extremely simple and familiar. But grappling for an object 2½ miles below the surface of the ocean, and hauling from a depth so great, are operations which, till recently, have scarcely entered men's minds. Suppose a cable to have been *hooked*, let us consider for a moment what remains to be done

before it is brought to the surface. We may imagine it lying in a line on the sea bed B B′ B″, and that it is hooked at a distance one mile from the broken end—say at the point C.

FIG: 4.



Taking B as the end of the cable, we may regard that part of it which lies on the right of C as *fixed* somewhere about B″, while the portion to the left of C will be held down by the weight of the cable simply. This weight is about 14 cwt. per mile; but as it is distributed over the entire mile of cable, the pressure upon any limited portion of it is but small. Nevertheless, it is sufficient to cause a considerable amount of friction between the cable and the ground, and would therefore render necessary a strong force to overcome it. But this friction is much increased by the pressure of the superincumbent water, which, at the depth of 2¼ miles, amounts to upwards of 50 cwt. on every square inch of the cable's surface. Of course, such a pressure as this, if transmitted by a solid substance everywhere in contact with the end of the cable, would hold it as firmly as though it were in a vice; but owing to the easy mobility of the water, and the partial mobility of the particles of ooze, the friction is much diminished. It is still sufficient to add very materially to that caused by the weight of the cable pressing on the sea bed, and the force required to cause a mile of cable to slide over the bed would be much greater than is commonly supposed. To the force necessary to cause the cable to slide must be added the weight of so much of the cable as is lifted from the ground, shown in the diagram extending from A to A′, and calculated at the rate of 14 cwt. per mile: we have then an idea of the resistance offered to the grappling line at C. While C is but a short distance from the ground the strain on the cable will be but small; and so long as any slackness or irregularity in the cable remains anywhere near C, it will rise without any important increase of strain. But when the cable reaches the point C′, and the portions C A and C A′ are stretched tight, it is then that the resistances of friction and weight come into full play, and the question is, which will yield first; that is, when the grappling-iron is tugging at the point C′, will the

portion B A, perhaps half or three-quarters of a mile in length, *begin to slide*, or will the cable snap asunder? The answer to this question can be given by experiment alone. We have no means of ascertaining the "co-efficient of friction" betwixt the cable and the sea bed, and therefore the data for an *à priori* determination of the result are wanting. The engineers who witnessed the late experiments appear sanguine; nevertheless, we have the plain facts before us, that when the cable was lifted some distance from the bottom—if, indeed, it were lifted at all—the strain became so great as to break every line they used. The hauling lines and tackle they can make as strong as they choose; but the cable "is what it is," and nothing that engineers can do will make it stronger, or the resistance it has to overcome less.

We have all along taken for granted that the cable has really been "hooked." The evidence which guided the engineers to this conclusion appears to consist chiefly in the fact that there was a gradually-increasing strain upon the dynamometer. Now, the rate of increase of strain recorded in the journal of the expedition is precisely what might be expected to result from the gradual straightening of the hauling lines, in connection with the more disadvantageous position of the ship as it approached a line more nearly perpendicular to the cable itself; and as the hauling tackle always gave way at the moment when the cable was supposed to be leaving the ground, it is extremely doubtful whether the grappling-irons actually touched the cable, or whether it might not have been held down by some other body. As to whether the recovery of the late cable is possible or not, is altogether another question; but after three attempts to lay an Atlantic cable, and the third failure scarcely recorded before a fourth attempt is unanimously resolved on, one feels that we are in the presence of men who are threatening to expunge the word "impossible" from our vocabularies.

TRUFFLES AND MORELS.

BY THE REV. M. J. BERKELEY M.A., F.L.S.

(*With a Tinted Plate.*)

THOUGH truffles are a constant ingredient in all first-class cookery, and the humble hash is frequently flavoured with morels, I have often been surprised how very few in comparison have a definite knowledge of their nature, or even distinguish between them so far as to know which is which. It is easy, however, to point out very palpable differences, as, for example, the truffle grows beneath the surface of the soil, the morel always exposed; the one is more or less solid and sessile, the other hollow and seated on a long stalk; the surface of the one is hard and cracked into pyramidal wart-like excrescences, the other soft and pitted like a honeycomb; the one has the fruit internal, the other external. This is all very plain, so long as we keep to the common truffle of commerce; but when other truffles are taken into consideration, and when we look at the matter from a scientific point of view, some of these differences vanish, and we are even obliged to admit that there are certain truffles which approach very near in character to morels.

It is a great mistake to suppose that there are only a very few kinds of truffles. We have nearly forty distinct species in Great Britain, and France and Italy can boast probably of double that number, of which, however, only a few are considered as articles of food or condiments. Vittadini made us acquainted with the latter, and the Messrs Tulasne with the former, both in works of first-rate character, and of which that of Messrs. Tulasne can scarcely be surpassed for beauty of illustration and correctness of description, while the researches of Messrs. Broome and Thwaites, in the West of England, have made known to us far the larger portion of the British species. Few botanical researches, whether practical or scientific, require more patience and perseverance. Even with the help of a dog, the labour of collecting is by no means despicable, and where there is not this appliance, it is scarcely possible to estimate the amount of zeal and judgment which is necessary to secure specimens in such condition and number as may be available for accurate discrimination. The Italian dogs are trained to such a pitch of excellence, that the labour is much diminished. Vittadini had dogs so perfectly trained, that he had only to let them smell any particular species, and they would hunt for that alone. In England, it requires great watchfulness to prevent the dog swallowing the truffle which he has found; but the truffle poachers in Italy train their dogs so well, that they will

go into a wood, and fetch out the truffles uninjured, and without making the slightest noise. Truffles always command a good price in the market, and their collection would be very lucrative, were it a matter of less speculation and uncertainty. Occasionally a lucky hit is made, and in a few hours there is an excellent return for labour. A few years since, Mr. Broome hit upon a small but very productive plantation in Wiltshire, which had entirely escaped the notice of the truffle-hunters. He communicated his discovery to one of the Salisbury plain collectors, who afterwards told him that he obtained as many truffles from that spot as brought him ten pounds.

It is often supposed that truffles are found only under beech trees. This is, however, quite untrue. In Poitou far the most productive localities are young oak plantations, which are often made purposely on the downs, with a view to their natural production. A mixture of firs with oak or beech is not ineligible, and I have known truffles found in numbers under hazels.

Amongst other curious theories about their production, it has been imagined that they are derived from the juices of the roots of trees which have been pierced by insects. This has, perhaps, partly arisen from confusion with certain galls which grow on the roots of oaks, and partly from the fact that the site of truffles is often indicated by certain beetles which have been nurtured in the interior of old specimens, and which have either lately assumed their perfect state, or are hovering about the truffle-grounds with a view to deposit their eggs.

Truffles, with a very few exceptions, may be regarded as hypogæous fungi—that is, fungi developed beneath the surface of the soil, and in consequence completely masking their real affinities, which appear only on close inspection. All hypogæous fungi are not, however, truffles. Some are mere forms of common aerial fungi, strangely altered by their peculiar situation; while others are either hybernating forms or totally abnormal conditions of mycelium.

The truly hypogæous species, or such as produce perfect fruit beneath the surface of the earth, are divisible into three great groups, according as they are more or less nearly related—

1. To the higher fungi, as Agarics and Boleti;

2. To the ascigerous fungi, as Peziza, Helvella, and the Morels; and

3. To the true vesiculiferous moulds, as Mucor.

The last of these is a very small group, consisting of small obscure species, none of which are of any economical importance, and which would never be considered, in any popular point of view, as truffles. I shall, therefore, pass by these, and confine my attention to the two first groups.

The first contains a large mass of species, some of which are of considerable size, but of which none, as far as I am aware, is ever admitted into our *cuisine*, with the exception of the red truffle of Bath (Fig. 5), which has the merit simply of giving a dark colour to gravy, without improving it in point of flavour. This is free from warts externally, but has a few flat, branched fibres running over the surface. A closely allied species occurs occasionally either alone or amongst real truffles, which would be rejected at once, or if used at all could only be so in very small quantities, as it has a strong scent of assafœtida, and indeed is utterly detestable. In these truffles the hymenium is waved and branched in every direction, so as to present a large spore-bearing surface, though closely packed within a coriaceous covering, which has no immediate communication with the outer air. The spores are seated on distinct sporophores, and are not contained within asci as in truffles proper (Fig. 5*a*). Various modifications occur as to the nature of the hymenium, the shape and sculpture of the spores; and the outer coat, according to circumstances, is more or less attenuated, till in *Gauttieria* it vanishes altogether; and we have a close affinity with Sparassis, a genus which was illustrated in the Intellectual Observer, Feb. 1864.

In a few instances we have dark and sombre hues, but in many cases the species are variously coloured; while in *Hymenogaster carotæcolor* the whole is of a bright orange, and communicates a clear lemon tint to substances with which it is placed in contact. Most of the species are rather dry, but one at least abounds with a milky juice, and has the peculiar smell of some of the milky Agarics. As regards the truffles proper, which have their fructification contained in little transparent sacs or asci (Fig. 6), and the sporidia of which are often of a comparatively large size, and complicated in structure, so as to present interesting objects under the microscope, the modifications are not less numerous than in the first division. In the genus Tuber itself, which is the most typical, while *Tuber melanosporum*, the common highly-flavoured truffle of Paris, *Tuber æstivum*, the truffle of our own markets, and two or three species which are often confounded with it, have the surface warty and black. There are other species with rufous small warts, while *Tuber magnatum*, the pride of Italian gourmands, is smooth; and instead of the flesh being marbled with brown, as in ordinary truffles, it presents tints like those of pale beetroot. This, from its high qualities and rarity, always fetches a great price in the market, and is eagerly bought up by the rich. A friend who took some specimens to Vienna in the palmy days of Austria, was eagerly sought out by the emperor's chef, who gladly exchanged pound for pound with

the caravan tea of Russia, which was then realizing thirty-six shillings the pound. There are other truffles belonging to this second division which are largely consumed in some parts of Europe and Africa. The white truffle of the ancients, belonging to the genus Terfezia, which occurs in sandy plains about the roots of different species of Cistus, is eaten in large quantities, though it has little to recommend it. Some friends lately saw a large basket exposed for sale in Damascus, and I have received fine specimens from Mogador. As in the last group, the outer coat varies much in thickness, and in one or two genera, which approach very near to Helvella and its allies, it vanishes altogether, and while in *Hydnobolites cerebriformis*, which is much eaten in Bohemia, the hymenium of which is still complicated, there is merely a communication with the outer air by means of the sinuous cavities, in Sphærosoma the fructifying surface is almost entirely external, and simply tuberculated.

Like most articles of food which are not in general use, a taste for truffles is an acquired one; but those who are once accustomed to their flavour are mostly enthusiastic in their praise. Some persons, however, turn from them with disgust, declaring that they resemble nothing so much as an old shoe-sole stewed. Possibly they may have been so unfortunate as to meet with a specimen which had been attacked by the beetle *Leiodes*, which certainly does not improve their flavour. Amongst the various modes of preparation, none equals that of simply roasting them in ashes, when they retain their aroma perfectly, and are a great delicacy; as indeed they are when simply boiled, and sent up *en serviette*—a mode far superior to boiling in champagne or claret, which rather detracts from than adds to their excellence.

Truffles are, perhaps, far more common than is generally imagined, though, from their place of growth, they often escape notice in countries where truffle dogs are not kept. They decrease in frequency as the latitude becomes higher; but in the centre of England they are occasionally very abundant. The *sine quâ non* seems to be limestone, so far as the genus Tuber is concerned. For example, there is not a truffle to be found in the sand at Kew, while at Sion, on the opposite side of the river, they sometimes occur.

Attempts at cultivation have at present not been attended with success. The spawn of truffles proper is generally very small in quantity, and is said sometimes to be luminous at night, and seems rather impatient of disturbance. A truffle-ground with which I had been well acquainted for many years, which was extremely productive, and in which specimens occurred occasionally of an enormous size, entirely lost its fertility from having been dug over to procure a larger supply of

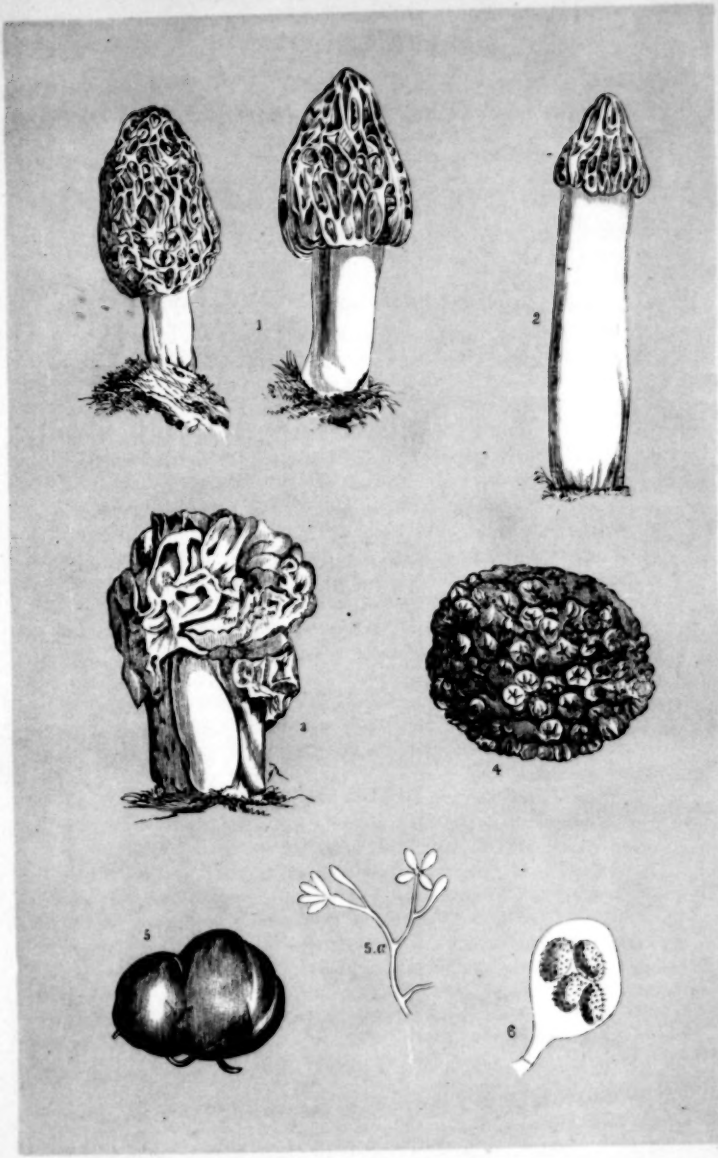
specimens. In some truffles belonging to other genera, the mycelium is abundantly developed, and white and filmy, so as at once to attract notice.

A few species only have been found in North America belonging to the two groups, and the same may be said of the southern hemisphere, from whence a small number has been received. The warmer parts of Europe, however, must be regarded as the most prolific region.

It is time to say a few words about morels, which have been associated with truffles in this article. The species are far less numerous than truffles, even if we include the Helvellæ, and a few of the higher Peziæ, which are intimately connected with them. Morels have a wide geographical range; they are abundant in some parts of India, as well as in Europe, and are largely collected and exposed for sale in the bazaars, and they are found in various localities, both of the Old and New World. The common morel, *Morchella esculenta* (Fig. 1), like most widely diffused species, assumes a great variety of forms, and is perhaps the only one of the genus which can be safely recommended as an article of food, though some of the Helvellæ and one or two Peziæ are not to be despised. *Gyromitra esculenta* (Fig. 3), though frequently eaten, is not always safe, a circumstance which may depend rather on peculiarity of constitution, than on any intrinsically deleterious properties. Morels are far more abundant in the south of England than they are as we proceed northwards. In some situations they occur in large quantities, and yield an excellent ketchup, but the most frequent use is either fresh and stuffed with minced veal or other white meat, or dried as a general ingredient in made dishes. Morels often occur where the ground has been charred, a circumstance which was so notorious in Germany, that the peasantry often burned the woods to promote their growth, insomuch, that stringent laws were passed to stop so evil a practice.

As regards structure, morels are far more simple than truffles proper, though more nearly allied to them than to the truffles of the first division. The hymenium consists of innumerable hollow threads arranged like the pile of velvet, some of which, called paraphyses, are very slender, with slightly incrassated tips, while the others are thicker, cylindrical, and very obtuse, and contain a single row of eight elliptic perfectly smooth sporidia, each of which has a large nucleus. The outer coat of these sporidia is never cellular or echinulate as in the allied truffles.

No attempts, as far as I know, have ever been made towards their cultivation, nor is it very likely that their delicate spawn would be able to be preserved like that of mushrooms, were it



TRUFFLES AND MORELS.

1.—Morchella esculenta.
2.—Morchella hybrida.
3.—Gyromitra esculenta.
4.—Tuber œstivum.
5.—Melanogaster variegatus.
6.—Ascus of Tuber rufum.

possible to get it to run. There is far more hope of success as regards truffles. Their artificial production would not only be a great horticultural triumph, but would be a source of ample remuneration.

OUR PLATE REPRESENTS,

1. *Morchella esculenta*, with a conical variety reduced to half the natural size.
2. *Morchella hybrida*, ditto.
3. *Gyromitra esculenta* (a small specimen).
4. *Tuber æstivum*, ditto.
5. *Melanogaster variegatus*, ditto. *a* Threads with spores on their sporophores.
6. Ascus of *Tuber rufum*, highly magnified.

OWEN ON THE VERTEBRATES.*

FOLLOWING up his *Lectures on the Comparative Anatomy and Physiology of the Invertebrate Animals*, Professor Owen now presents us with the first volume of another work, *On the Anatomy of the Vertebrates*, and when this work is completed he will have finished his *Outline of the Organization of the Animal Kingdom*. The volume before us commences with remarks on the modification of the vertebrate type amongst fishes, reptiles, birds, and mammals, and then proceeds to expound the anatomical characteristics of cold-blooded vertebrates designated *hæmatocrya*.† An amazing amount of information is compressed within the six hundred and fifty pages of this richly illustrated volume, which in itself deserves to be emphatically pronounced a great work, though it is not free from some scientific defects, and does not always display the best spirit towards certain anatomists and physiologists who are not entirely favourable to all the learned Professor's views.

In another preface, Professor Owen speaks of the several divisions of anatomical science, which he makes more numerous than sound logic requires. Neither the study of structure nor that of function is properly divisible into two parts, the one relating, as Professor Owen states, to existing animals, and

* *On the Anatomy of the Vertebrates.* Vol. i. "Fishes and Reptiles." By Richard Owen, F.R.S., Superintendent of the Natural History Departments of the British Museum, Foreign Associate of the Institute of France, etc. Longmans.

† The scientific use of Greek and Latin words is far too careless. In *Cryophorus* and *hæmatocrya*, the first half of the first word, and the last half of the second have the same derivation. The student translates the first word frost-bearer, while the second is not frosty blood, but only blood that is cooler than that of the birds and mammals.

the other to those which did exist in former times, but whose fossil remains alone bear witness to the fact that they once belonged to our globe. It is, no doubt, convenient for some purposes to make a division of this kind, but the comparative anatomist continually requires, not only all that is known, but more than is known concerning creatures that are extinct, in order to explain the real nature and true position of those which are now extant.

Although very few persons outside the medical profession study anatomy and physiology in an exact or profound manner, yet somewhat of the modes of thinking belonging to these great and complex sciences, together with some notion of their leading and elementary facts, ought to enter into general education; and such knowledge is indispensable to those who desire to become naturalists or microscopists to even a moderate extent. Very much in Professor Owen's new work will conduce to this end, and hundreds of readers to whom many details must remain unintelligible, will be able to derive both pleasure and profit from those portions which are easily understood.

Professor Owen always writes in a simple, good style. He introduces, indeed, a large quantity of technical terms, but he is careful to explain them, and he uses them for the rational purpose of precision, and does not intrude hard words where plain household English will do as well.

Noticing some of the "ways of anatomy" which he describes, we come to "Homological anatomy," which he defines "as seeking, in the characters of an organ and part (those chiefly of relative position and connection), that guide to a conclusion manifested by applying the *same name* to such part or organ, so far as the determination of the namesakeism, or homology, has been carried out in the animal kingdom. This aim of anatomy concerns itself little, if at all, with function, and has led to generalizations of high import, beyond the reach of one who rests on final causes. It has been termed grandiloquently 'transcendental' and philosophical; but any kind of anatomy ought to be so pursued as to deserve the latter epithet."

The statement that "this kind of anatomy concerns itself little, if at all, with function," will puzzle those who have received no initiation into this kind of philosophy. "What," they will exclaim, "call things by the same name without any regard to their uses or functions—this may be transcendental, but it can scarcely be philosophical." In ordinary life, if a thing is called a tea-pot, it is presumed to be a vessel to make tea in, and we should be astonished at the existence of tea-pots which their maker or designer never intended to be used for any purpose connected with the fragrant herb.

In reference to anatomy, the only popular notion is that connected with final causes—the idea that each specific thing was created especially to do exactly the kind of work which we see it perform; and as a corollary to this, it is popularly believed, and generally stated in books that possess "goodiness" rather than goodness, that we shall best understand the animal world by seeking to discover a specific use or service to be performed by every variety of structure which we can find. Nature thus viewed does not exhibit her noblest aspects. She appears rather as a series of clever contrivances to get over difficulties, than a grand and stately plan, instinct with reason, and working out an infinite variety of useful and beautiful results by the action of laws and properties regulating the whole cosmos, and which differ widely from a bundle of expedients to meet particular ends.

We shall endeavour, from Professor Owen's volume, to illustrate this question of "Homological anatomy." What two things, for example, can appear more distinct than a simple air-bladder or swimming bladder of a fish, and the lung of a human being? Professor Owen says "the organ so denominated is found in most osseous fishes in the form of an elongated bladder, tensely filled by air, extending along the back of the abdomen, between the kidneys and the chylopoietic* viscera, and sometimes beneath the caudal vertebra to near the end of the tail." This organ is sometimes bifurcate and sometimes still more complicated in shape, but "viewing the general modifications and relations of the air-bladder throughout the class of fishes, we cannot but discern and admit, notwithstanding some seeming capricious varieties, that its chief and most general function is a mechanical one, serving to regulate the specific gravity of the fish, to aid it in maintaining a particular level in its element, and in rising or sinking as occasion may serve." In ground fishes it is generally wanting, and their habits are accommodated to its absence. In sharks a great perfection of swimming apparatus makes them independent of it, and if it had been given to them it would, as Professor Owen explains, have "enslaved them as well as served them." It opposes, for example, those fishes "that possess it, in their endeavours to turn on one side, and it demands a constant action of the balancing fins to prevent that complete upsetting of the body, which it occasions from the weight of the superimposed vertebral column and muscles when life and action are extinct."

The first symptom of relation to the lung of the mammal, which we perceive, is in the connection of this air-bladder with the throat by means of a duct, the *ductus pneumaticus*. "The

* Viscera that concur to the production of *chyle*.

variation in respect to the presence or absence of an air duct is expressed," says Professor Owen, "in the characters and orders in the classification of Fishes."* "The duct which is shown by its place of communication with the beginning of the œsophagus, and by the rudimental larynx in *Polypterus* and *Lepidosiren*, to be the homologue of the trachea of air-breathing vertebrates, is a simple and delicate membranous tube, but it presents considerable variation in its length, diameter, and place of communication with the alimentary tract. In the herring, the *ductus pneumaticus* is produced from the posterior attenuated end of the cardiac division of the stomach; in many other fishes which possess it, its position is quite different."

The mucous lining of the air-bladder is the seat of vascular ramification, but the arrangement of the arteries and veins differs in different sorts of fishes, sometimes approaching towards, and sometimes receding from, the plans adopted in animals that possess genuine lungs. The contents of these air-bladders, likewise, varies. "In most fresh-water fishes it is nitrogen, and a very small quantity of oxygen, with a trace of carbonic acid gas; but in the air-bladder of sea-fishes, and especially of those which frequent great depths, oxygen predominates." The resemblance of the air-bladder to a lung is traced from fishes in which it has no respiratory functions at all, up to other kinds of fishes more allied to reptiles, in which it is so developed as to be "analogous in functions to the lung of the air-breathing amphibia." The action common to the lung, and to all forms of swimming bladders, is that of taking in air of some kind, although the mode in which they obtain it varies very much; the transition from a simple mechanical function like the cork of the swimmer, to the chemical and physiological function of respiration is striking enough, and the anatomist finds many similar instances of organs appearing under conditions as diversified. Such facts lead to wide conceptions of the unity of plan or design in nature. They certainly do not, as some have feared, detract in any way from the arguments of natural theology; but, taken in conjunction with, and often correcting the more popular forms which that argument has assumed, they give it a higher development and a greater force.

One result of the mode of reasoning we have endeavoured to illustrate, as belonging to "Homological Anatomy," is to establish a conviction that when once any form, or organ, or structure, however simple and apparently humble, is introduced into the great scheme of nature, a potentiality and possibility of indefinite advance and progress seems to accompany it. The simplest rudimentary lung does not breathe, the sim-

* These are given in the Professor's work.

plest rudimentary eye does not see, the simplest rudimentary ear does not hear, the simplest brain does not perceive, and when we come to the highest exhibitions of organs and functions which the relics of past worlds, or the existing objects in our present world, present to our view, we may regard them as no more than faint shadowings of some ulterior perfection, that in its due and pre-appointed season may be expected to arrive.

Professor Owen's book is divided into twelve chapters—the first, introductory; the second, on the osseous system of the *hæmatocrya;* after which, their muscular systems, their nervous systems, digestive, absorbent, circulatory, respiratory, and other systems, are in due order expounded. Such a book, from an author of such acknowledged learning and skill, cannot fail to meet with a wide appreciation; but as our readers comprehend a wider range of inquirers than have hitherto supported any scientific periodical, we shall take the opportunity of endeavouring to enlist the sympathies of those who may know least of these questions, in favour of the present work, as it is far better for those who only require a moderate quantity of information on difficult subjects, to glean what they can from first-class books, than to depend too exclusively upon popular expositions, which are too apt to be shallow and incorrect.

A very interesting branch of study makes us acquainted with the divers modes in which nature can accomplish any special result. Naturalists, destitute of profundity, speak as if nothing but the particular pieces of apparatus they see in particular creatures would enable them to get a living, or perform their ordinary work. It is quite true that special structure may disqualify an animal for living in given situations; but the modes by which creatures can be fitted for such situations are infinite in their variety. If, for example, we look at the vertebral column in several of its forms, we find rigidity and inaptitude for directly assisting motion carried to an extreme in such a creature as a tortoise; but similar bones, modified in a special way, make the vertebral column of the serpent a wondrous instrument of locomotion. "Serpents," says Professor Owen, "are too commonly looked down upon, as animals degraded from a higher type; but their whole organization, and especially their bony structure, demonstrate that their parts are as exquisitely adjusted to the form of their whole, and to their habits and sphere of life, as is the organization of any animal which we call inferior to them. It is true that the serpent has no limbs, yet it can outclimb the monkey, outswim the fish, outleap the jerboa, and, suddenly loosing the close coils of its crouching spiral, it can spring into the

air, and seize the bird upon the wing: all these creatures have been observed to fall its prey. The serpent has neither hands nor talons, yet it can outwrestle the athlete, and crush the tiger in the embrace of its ponderous overlapping folds. Instead of licking up its food as it glides along, the serpent uplifts its crushed prey, and presents it, grasped in the death-coil as in a hand, to its slimy, gaping mouth. It is truly wonderful to see the work of hands, feet, and fins, performed by a modification of the vertebral column."

A curious inquiry for the naturalist and physiologist relates to the probable sensations which animals differing widely from man receive from their organs. In the fish world we have abundant specimens of highly-developed eyes; but in the lowest fishes, the lancelet and the myxine, the eye is as simple as in the leech—"a minute tegumentary follicle is coated by dark pigment, which receives the end of a special cerebral nerve." A vague sense of light, without the slightest recognition of form or colour, is probably all that this humble instrument can enable its possessor to arrive at, still the function is that of which we should call sight; but how is John Hunter's question, "Is the mode of smelling in fishes similar to that of tasting in other animals?" to be answered? The fluid element in which the fish dwell carries over their so-called smelling apparatus whatever substances the water has in suspension or solution, and how does it affect the fishes' sensorium? Do they smell in the sense in which we smell? or do they taste with their noses? or do they do both in some mixed fashion?

The hearing of fishes probably ranges from a low perception of sound to a discrimination of tones, in those fishes (the gurnards, for example), which, by a peculiar mechanism in their air-bladders, are able to utter a certain range of musical notes. Amongst these creatures, are bad performers hissed, and good ones applauded and encored? In most fishes, in addition to a complex hearing apparatus, "otolites," or ear-stones—that is, small masses of carbonate of lime—float in a fluid cavity, and by their motions assist the auditory process, probably by reinforcing sound. A small transparent slug shows these otolites—which do not exclusively belong to fish—very well. He should be gently squeezed in a compressorium, or live-box, and examined with an inch or two-thirds. The auditory cavity, with these little bodies in active motion, will soon be discovered.

The teeth of the cold-blooded vertebrata are elaborately illustrated by Prof. Owen, and a great many of them in section afford splendid microscopic objects. One class of extinct fishes, the *Dendrodont*, or "tree-toothed," are remarkable for

the beautiful convolutions of structure which their sections present. The fish world exhibit teeth of a variety of shapes, the conical being the predominant. "As to number, they range from zero to countless quantities." Sometimes their teeth are slender, sharp-pointed, and so numerous and closely aggregated, "as to resemble the plush or pile of velvet"—all the teeth of the perch are of this kind; they are called "villiform." When equally fine and numerous, but longer, they are named "ciliiform;" and rather stronger, are "setiform," bristle-like. The pike presents specimens of rasping teeth; and in the pharyngeal bones of the wrasse —a common aquarium fish—"hemispherical teeth are so numerous, and spread over so broad a surface, as to resemble a pavement." All these matters may be easily verified by our readers; and microscopic preparations of fish-teeth, of various sorts, would form a very interesting collection.

THE HUMMING-BIRD HAWK-MOTH.

BY THE HON. MRS. WARD.

(With a Coloured Plate.)

The entomologist who may chance to look at the garden scene in our plate, and to read the article which it illustrates, will probably find nothing new—nothing that memory and imagination would not supply, were the following words only to be said, "*Macroglossa stellatarum*, abundant in 1865." The charming moth to which that name belongs would at once present itself to the mind's eye and ear, with its rapid flight, its graceful poising on wing, its brilliant eyes and long proboscis, its singular black and white plumes and velvety bird-like tail, and the loud peculiar humming noise of its wings. Its classified position among the insect tribes would be present to the recollection, and its long composite name would be too familiar to arouse criticism.

But the case of the reader who is *not* an entomologist is different. Such a reader may perhaps have pursued other branches of knowledge with great diligence, and may feel perfectly at home in any discussion arising about them, yet till this year may have attached no idea to the word *moth*, than that it appertains to the tiny devastator of our raiment, and to a few larger dingy creatures that point a moral by coming at the evening hour to imperil their lives around our candles. How startling to an intelligent observer of this kind was the

sudden discovery last summer that a beautiful creature exists, resembling a very small humming-bird, and seeming to hold a place above most insects in power of flight, and in symptoms of intelligence. What can it be? was the question asked, perhaps by hundreds of observers, in various parts of the British isles. The numerous newspaper paragraphs which appeared on the subject after a while supplied the *name*, "Humming-bird Hawk-moth." "Oh, that must be our friend," was the comment immediately made. Possibly, further information was desired; and as it may not have been obtained by observers not happening to be possessed of entomological books, I will briefly state here a few particulars about the moth's name and its place in the insect world, before proceeding to record the fact of its unusually frequent occurrence in 1865.

It is the "*Sphinx stellatarum*" of Linnæus and other writers, but now called *Macroglossa stellatarum*, its English appellation being "Humming-bird Hawk-moth." The name, Hawk-moth, belongs not only to this insect, but to several other genera; for instance, there is the Death's-head Hawk-moth, the Elephant Hawk-moth, etc. They are distinguished by the strength and peculiarity of their hawk-like flight, and often by their large size. Most of the hawk-moths have long bodies and comparatively small wings; the hinder pair, especially, being small in proportion to the size of the insect. The caterpillars of some of these moths are of remarkable aspect, especially that of the Privet Hawk-moth. This caterpillar can assume an attitude which reminded Linnæus of the figures of that fabulous creature, the sphinx, and hence he bestowed the name "sphinx" on the hawk-moths. The caterpillar of the Humming-bird Hawk-moth is not very remarkable in appearance; its colours are green, white, yellow, and a dusky hue, arranged in stripes;* it feeds on different kinds of *galium* and *rubia*, and the *galiums* being stellate plants, suggested the name "*stellatarum*." The name, Humming-bird, speaks for itself. More than once it has actually been mistaken for a small humming-bird by persons who had seen the latter in America, so curiously similar are the gestures of the bird and the insect.

"*Macroglossa*," the generic name of the moth, of course denotes the long tongue or proboscis which it possesses. This length of proboscis is observable also in some of the other hawk-moths; and Mr. Westwood notices the interesting connexion which exists between the variation in the length of the spiral tongue and the rapidity of flight possessed by these

* A figure of the caterpillar, resting on a stem of *Galium aparine*, or goose-grass, will be observed in the plate.

insects, depending as it does on their habit "of extracting the nectareous juices of tube-bearing flowers by means of their elongated proboscis."* The description given by Kirby and Spence of the proboscis with which moths and butterflies are supplied, applies so well to that of the insect at present under consideration, that I will repeat it:—

"The innumerable tribes of moths and butterflies eat nothing but the honey secreted in the nectaries of flowers, which are frequently situated at the bottom of a tube of great length. They are accordingly provided with an organ exquisitely fitted for its office—a slender tubular tongue, more or less long, sometimes not shorter than three inches, but spirally convoluted when at rest, like the mainspring of a watch, into a convenient compass. This tongue, which they have the power of instantly unrolling, they dart into the bottom of a flower, and as through a siphon, draw up a supply of the delicious nectar on which they feed. A letter would scarcely suffice for describing fully the admirable structure of this organ. I must content myself, therefore, with here briefly observing that it is of a cartilaginous substance, and apparently composed of a series of innumerable rings, which, to be capable of such rapid convolution, must be moved by an equal number of distinct muscles; and that, though seemingly simple, it is in fact composed of three distinct tubes—the two lateral ones cylindrical and entire, intended, as Reaumur thinks, for the reception of air; and the intermediate one, through which alone the honey is conveyed, nearly square, and formed of two separate grooves projecting from the lateral tubes; which grooves, by means of a most curious apparatus of hooks like those in the laminæ of a feather, inosculate into each other, and can be either united into an air-tight canal, or be instantly separated, at the pleasure of the insect."†

It is curious to observe the great variety which exists in the size of this organ, when we compare various moths. I collected the moths of the King's County several years ago, to the number of about a hundred and twenty distinct kinds; and a slight examination of this collection (still in pretty good order) enables me to verify this remark. The fact is, that some moths and butterflies take no food in the perfect state, and the mouth organs are therefore small and rudimentary. Corresponding variations (says Westwood) of course occur in the development of the digestive organs, and he notices that in some of the hawk-moths, "in which the spiral apparatus attains its greatest length, nearly equalling that of the entire body, the stomach is scarcely smaller than it is in the pupa

* *British Moths and their Transformations*, p. 5.
† *Introduction to Entomology*. Seventh edition (1857), p. 222.

state; whereas in the *Dendrolimus pini*, in which the parts of the mouth are atrophied, with the exception of the labial palpi, the stomach is almost obsolete."*

I have given prominence to my description of *Macroglossa's* proboscis, because (as will presently be seen) my correspondents have paid especial attention to this singular organ, and been struck by the beauty of its form and movements.

I need not enter into any formal description of the moth, as I have depicted it with great care in my plate from real specimens, one caught by me in 1845, at Ballylin, King's County, and two of the others secured at different places during last summer.† The specimen represented lowest in the plate, shows the under side of the insect; and the attitude of the resting moth at the right was taken not merely from a preserved specimen, but from life. The moth threw back its antennæ, remained perfectly still, and allowed me to gain a good idea of its profile, which was strangely like that of a hare or rabbit, when this position was assumed.

The upper figure, also represented partly in profile, gives a good idea of the moth's head, and illustrates the description of the insect which, as may be remembered, was given among the "Notes and Memoranda" of the INTELLECTUAL OBSERVER for last September, in a paragraph by Mr. C. S. Beckett. This description is so happy, that I may be excused if I repeat a few words of it. "One even visited my bouquet, and most unceremoniously rifled the sweets of one flower after another, as I held them in my hand, thus giving me an opportunity of closely observing its manœuvres, the vigilance of its hawk-like eyes, the accuracy with which it inserts its long flexible proboscis into each flower, and its mouse-like head and body. Another day I watched it unerringly dip its needle-tongue into the base of each petal of a carnation."

My plate also illustrates some of the remarks made in the numerous accounts of the moth which I have received from friends in various counties. I shall presently quote a few of these, as they give the impressions of the beholders with much freshness and spirit.

The account I have generally received in answer to inquiries is, that my correspondents had never seen it before, but had repeatedly observed it last summer, indeed from the beginning of June to the 16th of November, these being the earliest and latest dates which I have received. The abundance of *Macroglossa* has been notified to me by entomologists,

* *Introduction to the Modern Classification of Insects*, p. 313.

† I have never happened to meet the caterpillar, and have therefore copied it from the work of Humphreys and Westwood, *British Moths and their Transformations.*

as well as by those who had never, till this year, observed any insect with attention. For instance, an entomologist in the West Riding of Yorkshire, who had made a large collection of the moths of his district, informs me that the Humming-bird Hawk-moths were more common in his neighbourhood during 1865 than they had been for twenty years. He adds, that he finds them the most difficult of all insects to catch from their rapid flight, and that he has never succeeded in finding the caterpillar.

It is a well-known fact among entomologists that different kinds of insects have from time to time appeared in unusual numbers, or been unusually scarce, without any assignable reason. Various instances might be cited from entomological works, and some also from my own observations in past years, and various surmises as to the kind of season likely to produce the above-mentioned abundance or scarcity, might be added, but I prefer merely to complete, as far as my materials permit, the record of this hawk-moth's proceedings in 1865.

It was seen in Yorkshire, Derbyshire, Huntingdonshire, Somersetshire, Hampshire, Devonshire, Dorsetshire, Warwickshire, Middlesex, and doubtless in many other English counties. It was also very abundant near Glasgow, on thistles, etc., and in various other parts of Scotland. In Ireland, I have heard of its abundant appearance in the counties of Galway, Leitrim, Clare, Tipperary, Kerry, Dublin, Wicklow, Wexford, Kildare, Westmeath, and the King's and Queen's Counties.

"On the 10th of October," writes a correspondent in the county of Kildare, "I saw one in my own garden. It was sipping Penstemon blossoms. I caught it in one of the long bells. The moth lay on my hand apparently dead; the long proboscis curled up like the spring of a watch, and was withdrawn very slowly. In about five minutes it flew off again."

This habit of our moth was noticed long ago by the author of the *Journal of a Naturalist*, who says, "I have known this creature, like some other insects, counterfeit death when apprehensive of danger, fall on its back, and appear in all respects devoid of life when in a box; and as soon as a fit opportunity arrived, dart away with its usual celerity."*

Gardens and pleasure-grounds appear to have been its favourite haunts. "A long walk might be taken in the fields, and very few specimens seen;" so I am informed by a correspondent in the county of Clare.

A paragraph in the *Field* states, "Wherever there has been a jessamine, or a bed of geraniums in bloom, Humming-bird Hawk-moths have swarmed. Some correspondents have counted forty or fifty at a time."

* *Journal of a Naturalist*, p. 286. Murray, 1830.

From the county of Westmeath I hear: "I always saw two of the moths together, generally about noon, when the sun was shining brightly; they fluttered about the little pink annual 'Saponaria,' then in flower, and I have seen them perch on it for an instant. Their bodies were quite distinct, but their wings 'all in a whirr' from their rapid vibration. The colours were black, grey, and orange."

"They show in flying," says a correspondent in the King's County, "a very black tail, broad and well cut, short and even, light grey on the body and wings, with a kind of buff-coloured under-wing; the eye bright, and large for the insect, and the proboscis beautifully fine, with great capability of bending."

Another correspondent from the same county writes: "I first observed it late one summer evening, I think early in July. Its movements were so quick, and it darted about from flower to flower with such rapidity, that the eye could hardly follow it, making as it flew a loud and very deep humming noise, quite like a humming-top. It was then on a bed of Saponaria, and I observed it always chose long-necked flowers that the poor lumbering bees could hardly get their noses into. I first saw it, as I told you, late in the evening, and thought it was a night-moth; therefore great was my astonishment next morning, and every fine day afterwards, till *November*, to see it as busy as ever. It was very pretty when flying, its buff underwing making it look bright-coloured, its tail spread out, and its body speckled so beautifully with clear white and black feathers; and such bright eyes! Its greatest beauty, however, consisted in the marvellous proboscis, which it plunged with such unerring nicety into each blossom, never resting while doing so; and you know how small an aperture there is into the little Saponaria flower."

The black and white feathers spoken of in the above description, are represented in the plate. These ornamental tufts, with the blunt, bird-like tail, can be expanded at the pleasure of the insect; and an entomologist, when preserving a specimen of the Humming-bird Hawk-moth, will take care to show them to advantage by spreading them out neatly as the specimen dries.

My correspondent continues: "I have counted six at a time, evidently males and females, as some were always brighter than others."

On the subject of these moths congregating in a garden, a letter from Warwickshire contains this remark: "I do not think they keep together much, for though I have seen three or four at the same time in a small garden, they still seemed to be quite independent of each other, and ignorant of their

proximity." A friend in the county of Clare makes an exactly similar observation.

The air was in truth filled with these charming moths. I am told that in parts of Switzerland they are common every summer; and it has been suggested that they would probably be abundant in this country also each year, were it not for the young being destroyed by weather. It is therefore not unreasonable to suppose that the long fine summer of last year was favourable to the lives of the Humming-bird Hawk-moth caterpillars and their attainment of the perfect state.

Nevertheless, the fact remains, that fine seasons have often been accompanied by a scarcity of wasps, and that a beautiful butterfly, the Painted Lady, has appeared in profusion in particularly ungenial years, and that in districts where it has in general been scarce.

The keenest entomologist (to quote a writer already referred to) would not perhaps much lament the absence of this beauty, if such cheerless seasons were always requisite to bring it to perfection. Far pleasanter are the ideas connected in our minds with the Humming-bird Hawk-moth, that gay and graceful creature which came to delight us in the long bright summer weather of 1865.

RESULTS OF METEOROLOGICAL OBSERVATIONS MADE AT THE KEW OBSERVATORY.

LATITUDE 51° 28′ 6″ N., LONGITUDE 0° 18′ 47″ W.

BY G. M. WHIPPLE.

1865. Day of Month.	Reduced to mean of day. Barometer, corrected to Temp. 32.*	Temperature of Air.	Calculated. Dew Point.	Relative Humidity.	Tension of Vapour.	Temperature of Air. Maximum, read at 9·30 A.M. on the following day.	Minimum, read at 9·30 A.M.	Daily Range.	At 9·30 A.M., 2·30 P.M., and 5 P.M. respectively. Proportion of Sky clouded.	Direction of Wind.	Rain—read at 10 A.M.
	inches.	°	°		inch.	°	°	°	0—10		inches.
Oct. 1	...	...	...	...	...	68·8	50·8	18·0	...	...	0·000
„ 2	29·938	63·7	53·1	·70	·591	70·8	49·2	21·6	3, 0, 0	E, ENE, ENE.	·000
„ 3	30·165	62·4	52·5	·72	·566	70·3	54·8	15·5	0, 1, 0	ENE, E by N, E.	·000
„ 4	30·141	59·7	50·4	·73	·518	69·7	40·3	29·4	10, 0, 0	E, E by N, ENE.	·000
„ 5	30·035	57·7	42·4	·59	·484	65·5	40·6	24·9	0, 0, 0	ENE, NE by E, E by N.	·000
„ 6	29·997	57·7	37·7	·50	·484	65·8	41·3	24·5	0, 0, 0	ENE, E, E by N.	·000
„ 7	29·849	56·9	42·8	·62	·471	64·7	42·0	22·7	0, 0, 4	E, E by N, E by S.	·000
„ 8	...	...	...	...	...	66·3	49·3	17·0	...	...	·090
„ 9	29·352	59·2	57·9	·96	·509	65·8	53·8	12·0	5, 10, 10	SE by E, S, —.	·197
„ 10	29·309	57·9	54·7	·89	·487	64·0	48·6	15·4	3, 7, 9	SW by S, S by E, SSE.	·529
„ 11	29·260	57·0	53·0	·87	·473	63·0	55·3	7·7	8, 8, 8	SSW, SW by S, SW.	·607
„ 12	29·516	54·6	43·9	·69	·436	60·3	51·8	8·5	5, 2, 1	SW by W, W, SW by S.	·066
„ 13	29·659	49·1	45·9	·89	·362	58·4	34·4	24·0	10, 6, 1	—, W by N, NW by N.	·005
„ 14	29·955	49·7	48·4	·96	·369	58·9	41·5	17·4	9, 10, 10	—, —, —.	·000
„ 15	...	...	...	...	...	53·4	47·8	5.6	...	...	·053
„ 16	29·846	49·2	47·3	·94	·363	57·7	38·5	19·2	10, 10, 10	—, SSW, SSW.	·000
„ 17	29·268	54·3	50·2	·87	·432	60·0	41·6	18·4	5, 7, 3	SW by W, WSW, SW.	·594
„ 18	29·048	49·2	49·3	1·00	·363	53·4	43·7	9·7	10, 10, 10	NE, NE by E, NE.	·013
„ 19	29·150	42·3	40·3	·93	·286	45·9	44·7	1·2	10, 10, 7	NNW, WNW, W by N.	·777
„ 20	29·495	45·0	36·3	·74	·314	51.6	32·9	18·7	0, 5, 3	WSW, W by S, W.	·085
„ 21	29·630	42·1	42·0	1·00	·284	46·2	35·3	10·9	10, 10, 10	ENE, NE, ENE.	·115
„ 22	...	...	...	...	...	50·0	42·1	7·9	...	...	·236
„ 23	29·648	46·5	45·5	·96	·331	50·3	44·7	5·6	10, 10, 10	NE, N, —.	·776
„ 24	29·580	51·6	46·0	·83	·394	57·8	45·1	12·7	6, 6, 10	W, WSW, S by W.	·033
„ 25	29·578	51·4	38·6	·64	·391	56·6	46·1	10·5	5, 2, 2	WNW, WNW, NW by W.	·048
„ 26	29·346	51·1	51·0	·99	·387	57·7	38·4	19·3	10, 10, 10	S by E, SSW, SW.	·177
„ 27	28·999	46·5	45·0	·95	·331	56·5	45·7	10·8	1, 9, 2	SW, SW by S, —.	·679
„ 28	29·726	40·6	30·8	·71	·270	46·0	44.2	1·8	4, 0, 3	NW by N, W by N, W.	·067
„ 29	...	...	...	...	...	57·7	32·4	25·3	...	...	·071
„ 30	29·171	46·5	44·5	·93	·331	50·8	45·3	5·5	10, 7, 10	SE by S, SW by S, SW by S.	·364
„ 31	29·387	45·5	43·4	·93	·320	49·0	44·0	5·0	9, 10, 10	N by W, N, N.	·572
Daily Means.	29·579	51·8	45·9	·83	·406	...	...	14·5	...	...	6·154

* To obtain the Barometric pressure at the sea-level these numbers must be increased by ·037 inch.

HOURLY MOVEMENT OF THE WIND (IN MILES) AS RECORDED BY ROBINSON'S ANEMOMETER.—October, 1865.

Day.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Hourly Means.
Hour.																																
12	3	7	13	4	6	6	10	9	11		7	13	4	8	2	3	13	5	19	5	4	6	11	2	17	3	10	4	4	18	8	7·8
A.M. 1	4	7	7	3	9	9	11	11	9		8	15	4	7	2	2	12	3	19	5	5	11	11	3	18	2	12	7	3	18	6	8·1
2	4	5	11	3	9	7	8	14	7		8	15	3	7	2	3	13	2	16	3	2	8	9	2	20	2	14	11	6	14	9	7·9
3	6	5	10	2	2	7	9	12	5		12	17	1	4	5	4	12	3	17	7	2	9	8	5	20	3	10	18	7	11	7	8·0
4	7	5	9	2	2	8	8	13	6		11	19	2	3	2	4	11	3	14	8	2	11	7	3	21	3	11	20	9	11	10	8·2
5	7	4	8	2	2	6	6	16	3		10	16	2	3	2	3	9	4	12	6	2	13	8	3	17	6	12	20	9	8	7	7·5
6	7	5	8	2	4	7	4	7	6		9	16	2	2	2	3	10	3	17	6	3	14	7	4	19	7	10	20	18	6	8	7·9
7	7	8	10	1	6	7	10	9	6		10	19	2	1	4	2	12	5	19	5	4	14	8	5	19	7	14	17	24	5	9	8·9
8	4	11	12	1	15	6	10	8	8		12	20	1	4	7	3	18	4	16	8	4	14	6	9	24	10	15	17	27	4	11	10·3
9	4	14	15	4	16	10	16	7	13		15	18	1	3	5	4	17	6	17	9	7	17	7	12	26	15	16	16	26	5	14	11·8
10	10	16	16	6	16	15	20	10	15	12	15	24	2	3	7	2	19	8	19	13	8	18	7	19	28	23	22	15	30	5	17	14·2
11	15	17	17	6	16	20	18	14		13	16	21	9	2	6	3	16	9	16	16	10	16	10	17	25	22	20	17	24	9	15	14·4
12	18	13	19	10	20	20	19	14		15	19	21	6	3	10	2	14	9	20	14	9	17	9	18	25	21	19	13	27	18	18	15·3
P.M. 1	17	17	18	16	25	23	20	13		13	14	17	8	4	10	6	16	11	18	14	9	20	8	17	27	22	21	14	26	12	18	15·8
2	16	15	18	17	22	20	21	8		14	13	15	8	2	10	12	13	11	19	13	8	15	3	10	28	20	8	11	23	12	17	14·1
3	14	13	18	18	21	19	22	10		12	18	10	7	2	8	7	15	12	18	13	2	16	2	12	25	17	9	6	22	10	18	13·2
4	11	10	15	14	20	14	18	7		11	18	10	4	1	5	8	10	14	15	12	3	15	2	12	19	15	6	6	21	13	19	11·6
5	9	8	9	13	14	13	11	6		7	17	7	3	0	3	6	7	12	16	7	1	17	3	13	16	11	7	3	19	14	13	9·6
6	8	10	11	12	9	11	12	6		10	15	7	3	3	2	6	5	11	13	8	3	16	4	12	13	10	6	5	15	11	16	9·1
7	10	13	9	11	7	6	9	9		11	18	5	4	3	1	8	5	14	13	6	4	13	2	18	6	12	5	6	16	12	19	9·2
8	10	9	13	8	6	3	10	13		10	13	4	3	2	1	11	5	14	9	9	2	15	2	17	3	13	6	3	19	14	14	8·7
9	9	9	9	6	6	5	10	10		7	11	4	4	2	2	14	3	15	12	6	3	14	3	18	3	11	5	2	18	12	13	8·2
10	9	10	8	8	7	6	6	6	80	9	13	2	6	2	1	11	2	16	12	7	5	12	2	21	6	14	2	1	19	6	11	8·0
11	5	12	6	6	6	9	10	7		6	12	3	5	2	2	11	2	20	10	5	5	11	2	21	5	10	4	5	13	6	7	7·6
12																																
Total Daily Movement.	214	243	289	175	266	257	298	239	319		314	318	94	73	101	138	259	214	376	205	107	332	141	273	430	279	264	257	425	256	306	10·0

RESULTS OF METEOROLOGICAL OBSERVATIONS MADE AT THE KEW OBSERVATORY.

LATITUDE 51° 28′ 6″ N., LONGITUDE 0° 18′ 47″ W.

1865. Day of Month.	Reduced to mean of day. Barometer, corrected to Temp. 32°.*	Temperature of Air.	Calculated. Dew Point.	Relative Humidity.	Tension of Vapour.	Temperature of Air. Maximum, read at 9·30 A.M. on the following day.	Minimum, read at 9·30 A.M.	Daily Range.	At 9·30 A.M., 2·30 P.M., and 5 P.M., respectively. Proportion of Sky clouded.	Direction of Wind.	Rain—read at 10 A.M.
	inches.	°	°		inch.	°	°	°	0—10		inches.
Nov. 1	29·897	40·6	37·9	·91	·270	43·9	32·6	11·3	4, 10, 0	W by S, W, SW.	0·005
„ 2	29·996	39·8	35·6	·86	·262	48·8	26·7	22·1	10, 6, 8	—, S by W, S by E.	·005
„ 3	30·066	44·6	38·0	·80	·310	50·0	29·4	20·6	0, 6, 1	NW by N, NW by N, —.	·267
„ 4	30·178	41·1	36·3	·85	·274	49·4	30·1	19·3	0, 0, 0	—, N by E, NNW.	·006
„ 5	...	...	...	...	...	48·3	29·6	18·7	...	... ...	·005
„ 6	30·189	42·0	36·9	·84	·283	47·0	35·4	11·6	7, 8, 8	NE, N by W, N by W.	·006
„ 7	30·103	42·6	37·8	·84	·289	45·3	38·2	7·1	9, 10, 10	N by E, NNE, NE.	·000
„ 8	29·973	47·6	42·4	·83	·344	50·5	41·7	8·8	5, 9, 10	NE by N, NE by N, NE.	·059
„ 9	29·994	46·6	41·2	·83	·332	50·2	42·1	8·1	5, 10, 4	NE, N by E, N by E.	·000
„ 10	30·249	43·4	34·8	·74	·297	48·7	38·6	10·1	0, 1, 0	NW, NNW, NW by W.	·007
„ 11	30·291	43·3	38·4	·84	·296	47·1	31·7	15·4	10, 8, 10	SW, WSW, SW by W.	·000
„ 12	...	...	...	...	...	47·7	40·3	7·4	...	... ...	·000
„ 13	30·366	42·4	32·3	·70	·287	47·4	37·7	9·7	0, 1, 1	E, E, E,	·000
„ 14	30·091	46·0	44·7	·95	·325	52·3	34·4	17·9	10, 10, 10	ENE, SSE, SSW.	·000
„ 15	30·265	46·9	40·0	·79	·335	51·6	39·3	12·3	7, 2, 0	NW by W, NW by W, —.	·033
„ 16	30·242	41·5	37·7	·88	·278	48·7	28·6	20·1	9, 8, 4	NE by E, ESE, SE by E.	·000
„ 17	29·740	53·2	51·6	·95	·416	55·0	33·0	22·0	10, 10, 10	S by W, SW, WSW.	·043
„ 18	30·166	44·8	40·3	·85	·312	48·6	38·8	9·8	1, 6, 1	W, WSW, SW by S.	·209
„ 19	...	...	...	...	...	55·1	37·7	17·4	...	... ...	·027
„ 20	29·599	51·1	48·9	·92	·387	55·6	50·8	4·8	10, 10, 8	SSW, —, S.	·395
„ 21	29·302	50·8	46·7	·87	·383	54·7	49·0	5·7	9, 7, 6	SSW, S by W, S.	·050
„ 22	29·017	51·5	45·6	·82	·393	55·9	47·3	8·6	7, 6, 0	SW, SW, SW.	·162
„ 23	29·487	49·5	43·8	·82	·367	56·3	46·7	9·6	1, 9, 10	SW, —, SSE.	·039
„ 24	29·378	50·3	42·7	·77	·377	54·7	49·3	5·4	9, 2, 0	SW by S, SW, SW.	·085
„ 25	29·178	51·6	46·1	·83	·394	55·1	45·2	9·9	10, 10, 10	SSE, SSE, S.	·010
„ 26	...	...	...	...	...	49·7	45·2	4·5	...	... ...	·017
„ 27	29·709	40·0	37·7	·92	·264	47·7	31·6	16·1	10, 5, 6	NE, ESE, SSE.	·000
„ 28	29·174	46·6	44·6	·94	·332	48·8	32·7	16·1	9, 10, 10	SE by E, E, S.	·047
„ 29	29·587	44·0	40·4	·88	·304	47·7	45·5	2·2	10, 10, 9	WSW, W, SW by W.	·350
„ 30	29·958	43·8	41·8	·93	·302	47·8	39·7	8·1	10, 8, 1	NNE, N by W, NNW.	·031
Daily Means.	29·854	45·6	40·9	·85	·323	...	...	12·0	...		1·858

* To obtain the Barometric pressure at the sea-level these numbers must be increased by ·037 inch.

HOURLY MOVEMENT OF THE WIND (IN MILES) AS RECORDED BY ROBINSON'S ANEMOMETER.—November, 1865.

Day.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Hourly Means.
Hour.																															
12																															
1	3	3	7	4	1	10	13	12	20	5	4	3	5	10	11	1	11	10	9		24	12	23	18	9	26	6	15	1	4	9·6
2	6	4	4	2	1	13	9	14	19	5	4	3	6	11	11	2	11	8	9		23	13	28	19	10	28	6	16	8	5	10·3
3	6	3	2	3	1	10	13	13	19	6	2	4	8	11	11	1	10	10	8		27	11	23	20	10	19	6	20	10	4	10·0
4	4	2	2	3	2	3	8	11	15	20	6	3	4	13	11	10	1	13	3	13	28	14	21	25	12	16	5	21	10	5	10·4
5	6	2	4	4	0	1	9	14	16	17	7	3	4	12	11	12	0	15	6	14	23	19	20	26	9	16	8	20	10	3	10·6
6	4	1	4	6	2	9	13	16	14	10	1	3	11	11	12	2	16	6	15		20	22	22	24	7	16	4	19	8	2	10·4
7	6	0	4	3	0	6	12	12	16	7	4	3	14	6	11	1	20	6	18		23	26	18	28	14	18	2	20	10	3	10·7
8	5	1	3	2	1	7	15	13	12	7	3	2	12	7	13	1	20	6	22		21	33	17	25	11	18	1	23	10	3	10·8
9	6	1	4	2	1	9	15	11	14	8	4	1	13	5	10	3	21	5	19		23	38	13	30	10	21	2	22	10	3	11·2
10	9	1	6	2	1	10	17	12	19	7	4	4	17	6	13	2	21	5	20		18	43	15	35	12	18	4	18	12	4	12·2
11	10	2	6	4	2	16	14	17	19	9	9	6	22	7	13	5	22	8		16	22	43	14	28	16	20	2	21	13	1	13·3
12	10	2	8	3	2	16	18	17	15	10	4	4	21	10	14	8	21	6		14	20	50	18	37	17	17	4	19	13	4	13·8
1	8	7	10	5	9	15	21	19	16	9	7	3	24	13	14	13	22	6		14	18	42	12	40	23	12	8	19	14	7	14·8
2	8	7	9	6	11	12	20	17	18	11	10	3	24	12	13	11	18	6		11	23	40	11	42	26	14	10	17	14	8	14·9
3	6	7	9	5	11	13	19	17	17	9	7	4	22	10	10	8	14	5		7	20	27	6	32	26	12	11	12	14	8	12·7
4	4	7	4	4	7	12	20	18	15	5	9	2	27	12	4	7	10	3		5	22	28	4	28	27	6	11	7	9	6	11·1
5	5	5	3	1	3	12	21	21	12	5	6	3	25	14	4	8	10	5		8	14	23	7	23	28	7	10	10	11	9	10·8
6	4	4	2	4	7	14	20	22	15	5	7	5	19	14	3	5	13	5		11	14	23	6	20	29	7	8	7	8	6	10·6
7	3	3	2	0	6	11	19	22	15	3	6	5	16	12	3	13	10	4		10	14	21	10	20	33	6	12	9	10	6	10·5
8	4	6	4	1	6	14	21	20	12	2	7	6	16	12	4	5	11	4		7	16	23	10	17	32	4	14	6	8	5	10·2
9	4	4	2	2	4	9	19	20	14	3	7	4	15	9	5	5	7	2		10	19	23	10	7	35	7	10	5	7	6	9·4
10	4	3	3	1	5	11	21	21	10	3	7	5	11	10	2	9	7	3	439		12	15	20	9	8	31	6	11	4	6	9·0
11	4	2	3	2	5	12	17	22	12	4	5	6	10	13	2	12	7	7		18	15	27	7	7	35	7	12	2	7	8	10·0
12	4	4	2	1	4	11	11	20	9	5	4	8	12	13	2	12	5	9		20	15	23	12	7	31	8	11	1	6	7	9·5
Total Daily Movement.	133	81	107	65	94	269	393	407	369	151	127	95	375	250	207	145	335	138		749	477	644	336	566	493	329	178	333	229	121	11·3

RESULTS OF METEOROLOGICAL OBSERVATIONS MADE AT THE KEW OBSERVATORY.

LATITUDE 51° 28′ 6″ N., LONGITUDE 0° 18′ 47″ W.

1865.	Reduced to mean of day.					Temperature of Air.			At 9·30 A.M., 3.30 P.M., and 5 P.M., respectively.		Rain—read at 10 A.M.
			Calculated.								
Day of Month.	Barometer, corrected to Temp. 32°.*	Temperature of Air.	Dew Point.	Relative Humidity.	Tension of Vapour.	Maximum, read at 9·30 A.M. on the following day.	Minimum, read at 9·30 A.M.	Daily Range.	Proportion of Sky clouded.	Direction of Wind.	
	inches.	°	°		inch.	°	°	°	0—10		inches.
Dec. 1	30·020	43·7	40·9	·90	·300	45·2	41·6	3·6	10, 10, 10	NE, NE, NE.	0·007
„ 2	29·767	41·3	37·2	·86	·276	46·6	40·2	6·4	7, 3, 6	E, E by S, SE by E.	·006
„ 3	...	...	...	...	...	46·9	38·8	8·1	...	... ...	·000
„ 4	29·281	47·7	42·3	·83	·345	50·1	39·1	11·0	10, 8, 8	SE by E, SSE, SE.	·014
„ 5	29·672	46·5	42·1	·86	·331	49·6	42·9	6·7	10, 6, 10	S, SSE, SE by S.	·000
„ 6	30·002	49·5	47·0	·92	·367	52·8	44·7	8·1	10, 10, 10	SE by E, SSE, SE by S.	·007
„ 7	30·231	50·5	49·1	·95	·380	51·8	48·3	3·5	10, 10, 10	SSW, WSW, SSW.	·000
„ 8	30·556	46·3	44·3	·93	·329	48·1	45·3	2·8	10, 10, 10	—, W by S, —.	·215
„ 9	30·506	45·0	43·9	·96	·314	46·9	43·0	3·9	10, 10, 9	E, —, —.	·000
„ 10	...	...	...	...	...	43·8	38·2	5·6	...	... ...	·000
„ 11	30·687	42·2	37·0	·83	·285	45·7	39·7	6·0	10, 7, 4	NE, NE by N, N.	·000
„ 12	30·611	40·2	32·6	·77	·266	41·7	38·3	3·4	10, 9, 9	NE, NE by N, NE by N.	·000
„ 13	30·484	37·1	31·6	·82	·239	...	34·4	...	0, 1, 10	N, N, —.	·000
„ 14	30·455	41·3	35·0	·81	·276	45·2	35·0	10·2	0, 2, 0	W by N, W by N, WNW.	·000
„ 15	30·725	38·1	31·7	·80	·247	41·9	35·4	6·5	4, 7, 10	NNW, N by W, NW.	·000
„ 16	30·685	38·6	33·9	·85	·251	40·7	30·0	10·7	9, 9, 10	WNW, W, W by S.	·000
„ 17	...	...	...	...	...	44·1	36·2	7·9	...	... ...	·000
„ 18	30·481	39·1	36·8	·92	·256	42·2	38·7	3·5	10, 10, 10	W by N, —, —,	·000
„ 19	30·277	42·9	39·8	·90	·292	47·1	36·7	10·4	9, 10, 8	E by N, SE, SE by S.	·000
„ 20	30·232	43·9	42·5	·95	·303	50·1	40·6	9·5	10, 2, 0	S by W, SW, SW.	·000
„ 21	30·303	48·0	44·1	·87	·348	50·7	45·6	5·1	0, 8, 10	SSW, SSW, SW.	·000
„ 22	30·342	39·9	35·6	·86	·263	41·9	41·4	0·5	10, 9, 10	SE, S by W, SW.	·000
„ 23	30·405	39·3	35·6	·88	·258	41·9	38·7	3·2	10, 10, 10	S by W, SE by S, SE by S.	·000
„ 24	...	...	...	...	...	42·8	38·8	4·0	...	... ...	·000
„ 25	...	...	...	...	...	47·3	29·1	18·2	...	... ...	·002
„ 26	...	...	...	...	...	48·8	39·9	8·9	...	... ...	·000
„ 27	30·327	35·2	35·1	·99	·223	38·7	31·0	7·7	10, 7, 7	SW, —, —.	·010
„ 28	29·914	45·7	42·2	·89	·322	49·3	29·5	19·8	7, 10, 10	S, SW, S by W.	·010
„ 29	29·377	48·1	46·7	·95	·350	49·8	43·1	6·7	7, 10, 10	S by W, SSW, S.	·161
„ 30	29·753	40·1	33·4	·79	·265	43·4	36·0	7·4	1, 0, 1	SW, SW by W, SW.	·127
„ 31	...	...	...	...	...	51·1	38·0	13·1	...	... ...	·090
Daily Means.	30·212	42·9	39·2	·88	·295	...	...	7·4	...	...	0·649

* To obtain the Barometric pressure at the sea-level these numbers must be increased by ·037 inch.

HOURLY MOVEMENT OF THE WIND (IN MILES) AS RECORDED BY ROBINSON'S ANEMOMETER.—December, 1865.

Day.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Hourly Means.
Hour.																																
12	5	10	11	10		11	18	3	2	6	2	5	6	4	12	5	2	1	3		10	6	11	5	4		6		35	10	31	8·7
A.M. 1	3	9	15	13		5	18	3	5	4	0	6	3	3	7	5	2	2	2		10	7	8	3	2		4		31	13	36	8·1
2	2	9	14	14		9	16	5	5	3	1	9	2	7	11	4	3	2	1		10	9	8	5	4	211	2	78	30	12	37	8·7
3	2	8	13	19		10	18	5	4	3	1	13	2	8	16	3	2	3	3		8	10	8	5	3		1		22	12	40	9·0
4	3	11	13	20		10	19	2	1	3	5	12	4	8	13	5	4	2	2		9	11	4	5	1		2		22	11	43	9·1
5	2	11	12	20		10	15	2	5	5	6	10	4	4	11	3	5	1	2	155	8	8	4	5	3		3		26	8	44	8·8
6	3	14	11	16		11	15	2	4	5	7	10	5	4	11	5	5	0	6		8	12	3	6	7		2		24	12	41	9·2
7	5	8	13	13		12	13	3	4	6	3	8	5	6	9	7	5	1	6		9	14	4	4	7		3		25	15	41	9·2
8	2	15	9			11	15	1	5	4	7	7	3	4	9	6	6	3	5		10	14	3	2	7		2		20	17	46	8·6
9	5	13	10			12	15	2	4	3	3	10	4	4	10	7	5	1	7		11	10	4	3	9		4		25	17	35	8·6
10	6	14	10		13	15	14	1	4	2	7	15	10	10	10	6	5	3	7	15	15	13	6	5	11	15	2	22	28	21	35	11·2
11	5	14	10		11	10	12	4	2	5	10	12	7	5	9	8	6	2	7	12	15	14	5	2	11	18	2	24	30	21	36	11·0
12	3	12	12		14	12	14	3	1	3	12	13	7	7	11	8	4	1	11	10	15	13	4	3	15	19	1	25	37	20	30	11·3
P.M. 1	3	11	13		14	16	11	4	1	3	8	11	9	7	12	6	3	1	9	7	15	10	5	2	15	17	3	25	37	21	24	10·8
2	6	14	12		12	14	12	4	2	5	9	9	4	8	8	5	4	1	7	8	15	7	7	3		15	6	25	38	17	20	10·3
3	6	16	12		12	13	6	4	1	2	8	5	5	8	5	7	2	2	10	7	12	5	5	3		15		25	37	15	15	9·4
4	5	12	12		14	14	5	5	1	2	6	7	1	7	5	5	2	2	9	8	13	5	6	4		11		20	40	16	17	9·1
5	3	11	8		15	14	3	4	5	1	6	9	2	5	3	5	2	2	9	4	12	6	9	1		6		23	35	14	13	8·2
6	4	11	8		12	14	2	4	1	1	6	7	2	5	4	6	2	2	10	4	10	6	8	1		7		24	42	16	11	8·2
7	3	13	8		12	15	4	4	3	4	8	5	3	8	5	5	1	4	9	5	13	6	9	3		8		21	43	16	7	8·7
8	4	13	10		9	13	5	6	1	3	9	6	3	5	5	5	2	1	10	2	8	7	8	3		5		23	29	17	8	7·9
9	9	15	9		13	15	2	1	1	1	6	5	3	10	6	2	4	2	8	4	8	6	5	3		7		27	24	17	7	7·9
10	10	17	9	398	12	18	4	3	4	5	8	4	4	7	4	4	2	2	6	5	7	9	10	4		7		30	13	30	12	8·9
11	10	14	9		9	15	3	1	4	3	9	6	3	6	3	2	3	2	10	9	6	8	5	4		8		30	10	30	12	8·4
12																																
Total Daily Movement.	109	295	263	695		299	259	76	70	82	142	204	101	150	199	124	81	43	159	255	257	216	149	84	468		465		703	398	641	9·4

RESULTS OF METEOROLOGICAL OBSERVATIONS MADE AT THE KEW OBSERVATORY.

LATITUDE 51° 28′ 6″ N., LONGITUDE 0° 18′ 47″ W.

MONTHLY AND ANNUAL MEANS FOR THE YEAR 1865.

Month.	Barometer, corrected to temp. 32°.*	Temperature of Air.	Dew Point.	Relative Humidity.	Tension of Vapour.	Daily Range.	Total Fall of Rain.	Month.	Barometer, corrected to temp. 32°.*	Temperature of Air.	Dew Point.	Relative Humidity.	Tension of Vapour.	Daily Range.	Total Fall of Rain.
	inches.	°	°		inch.	°	inches.		inches.	°	°		inch.	°	inches.
January	29·536	37·0	33·5	·89	·241	9·7	3·098	August ...	29·841	59·6	52·2	·78	·520	17·1	4·342
February ...	29·880	36·5	32·0	·85	·240	9·0	1·945	September.	30·201	64·5	54·6	·72	·614	20·5	0·468
March.....	29·897	36·4	29·2	·78	·235	10·8	0·810	October ...	29·579	51·8	45·9	·83	·406	14·5	6·154
April	30·099	53·8	43·1	·71	·434	21·6	0·449	November .	29 854	45·6	40·9	·85	·323	12·0	1·858
May.....	29·906	55·8	45·8	·72	·462	18·4	3·275	December..	30·212	42·9	39·2	·88	·295	7·4	0·649
June	30·167	60·5	50·6	·73	·541	19·4	1·579								
July.....	29·931	63·6	54·6	·74	·597	18·5	1·817	Mean	29·925	50·7	43·5	·79	·409	14·9	26·444

* To obtain the Barometric pressure at the sea-level these numbers must be increased by ·037 inch.

TABLE SHOWING THE MEAN VELOCITY OF THE WIND FOR EACH HOUR OF THE DAY IN THE DIFFERENT MONTHS OF THE YEAR 1865 (IN MILES PER HOUR).

	A. M.												P. M.											
Hour.	12 to 1	1 to 2	2 to 3	3 to 4	4 to 5	5 to 6	6 to 7	7 to 8	8 to 9	9 to 10	10 to 11	11 to 12	12 to 1	1 to 2	2 to 3	3 to 4	4 to 5	5 to 6	6 to 7	7 to 8	8 to 9	9 to 10	10 to 11	11 to 12	Mean.
Jan.	10·3	10·1	9·9	10·8	11·9	10·7	10·8	11·0	10·8	10·3	11·7	12·4	13·1	12·6	12·7	11·9	11·7	11·1	12·1	12·5	11·5	11·1	11·4	10·5	11·3
Feb.....	11·0	10·4	10·6	11·1	12·1	11·6	11 0	9·9	10·5	10·9	13·6	12·8	13·1	13·7	13·7	14·0	13·4	12·0	11·1	11·2	10·8	11·2	11·5	11·1	11·8
March ...	10·1	10·1	9·3	9.0	9·8	10·8	9·7	10·7	11·9	13·7	15·8	17·1	18·3	18·1	17·9	17·5	16·5	14·7	13·3	12·3	11·4	11·3	11·0	10·4	13·0
April	7·4	6·5	5·9	6·8	6·8	6·0	6·9	7·7	8·8	9·5	10·6	11·7	12·4	11·8	12·8	13·2	13·4	12·5	11·2	10·2	9·6	8·7	8·8	7·5	9·4
May.....	6·5	6·0	6·2	5·3	5·8	5·5	6·6	8·6	8·8	10·1	11·6	11·8	12·5	12·3	13·4	12·4	12·8	10·8	9·3	7·9	6·2	5·8	6·7	6·3	8·8
June.....	5·9	6·1	5·3	5·5	5·3	5·9	7·7	7·8	8·6	9·3	10·0	10·3	10·8	11·1	10·1	9·8	10 6	10·4	9·4	8·4	8·1	7·4	7·4	6·3	8·2
July.....	6·0	5·5	5·8	6·1	5·5	6·1	7·3	8 9	10·2	11·0	12·3	12·5	13·7	13·9	13·4	13·5	13·8	12·0	10·5	8·8	7.3	6·4	6·3	5·2	9·2
August...	5·3	5·0	4·6	5·0	5·5	6·0	7·0	8·8	9·7	10·8	12·0	12·2	11·5	11·7	11·5	11·4	11·1	9·4	8·0	6·8	6·1	6·0	6·0	5·5	8·2
Sept. ...	4·4	4·0	4·0	3·4	4·1	4·3	4·9	5·4	5·7	6·9	9·7	10·7	12·5	12·6	12·8	12·1	11·4	8·6	7·8	7·7	6·4	5·6	5·1	4·1	7·3
Oct.	7·8	8·1	7.9	8·0	8·2	7·5	7·9	8·9	10·3	11·8	14·2	14·4	15·3	15·8	14·1	15·2	11·6	9·6	9·1	9·2	8·7	9·2	8·0	7.6	10·0
Nov.....	9·6	10·3	10·0	10·4	10 6	10·4	10·7	10·8	11·2	12·1	13·3	13·8	14·8	14·9	12·7	11·1	10·8	10·6	10·5	10·2	9·4	9·0	10·0	9·5	11·3
Dec.	8·7	8·1	8·7	9·0	9·1	8·8	9·2	9·2	8·6	8·6	11·2	11·0	11·3	10·8	10·3	9·4	9·1	8·2	8·2	8·7	7·9	7·9	8·9	8·4	9·4
Mean.....	7·7	7·5	7·3	7·5	7·7	7·8	8·3	9·0	9·6	10.4	12·2	12·6	13·3	13·3	12·9	12·5	12·2	10·8	10·0	9·6	8·6	8·3	8·4	7·7	9·8

NOTES ON BYSSUS.

BY T. GRAHAM PONTON.

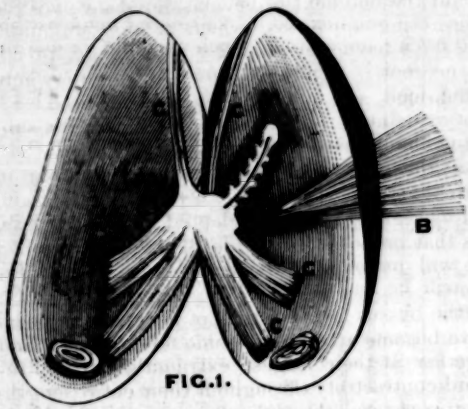


FIG. 1.

FIG. 2.

FIG. 1.—Foot and Byssul Muscles of Mussel. A, Foot; B, Byssus; C, C, Muscles.

FIG. 2.—Under Side of Foot enlarged; a Portion of the Integument removed. A, Groove; B, Substance of the Foot uncovered; C, Glandular Portion.

BYSSUS is the name given to the peculiar threads, by means of which certain of the mollusca fasten themselves to the rocks. The substance is a very peculiar one, varying very much in appearance and texture, being sometimes black, as in the mussel; sometimes of a golden brown, as in the pinna; sometimes hard and stiff, and sometimes soft and silky.

It is a very curious and interesting experiment to watch the mode in which this substance is formed, which is much as follows:—On cutting away the byssus from one of the attached mollusca, the common mussel, for instance, you will observe that the animal will soon after protrude a small finger-like object from the side of its shell; this is the foot.

You will then notice that the point of the foot will be placed against the glass in which the animal is confined, and suddenly withdrawn with a peculiar sort of jerk. If you now look very closely at the point of the foot, you will see a fine white thread stretching between it and the glass. This is the first thread of the new byssus.

The process is repeated at intervals, a fresh thread being formed each time, until the byssus is restored to its original state. Such is the mode in which the byssal threads are attached by the animal to the rocks, but the most curious part of the question yet remains unsolved.

The process just described is, so to speak, a purely mechanical one, but the one next to be considered involves the existence of a secreting apparatus, which is quite unique in animal economy. We have seen that the threads are spread, as it were, by the foot. We have now to inquire where these threads are formed, and of what they are composed.

Two modes of explaining the formation of this curious substance are in vogue among naturalists.

The first, and the one which has found most favour in England is, that the byssus is the result of a peculiar exudation, which is secreted by a gland specially adapted for the purpose.

The second is that proposed by M. de Blainville, a detailed account of which will be found in the first volume of his *Manual de Malacologie*.

He considers the byssus as consisting of fibres of the pedal muscle which have become attached to some foreign body, and agglutinated together at their largest extremity, but still retaining vitality and contractility throughout their entire length. As regards the latter theory, the difficulties connected with it are so great as to be almost insurmountable. For, although perhaps not impossible, yet it would be an extraordinary thing for muscular fibre of this kind to be reproduced, after being entirely cut away; which byssus, as we have seen, undoubtedly is. And moreover, the byssus threads are, so far as I can discover, neither living nor contractile, as De Blainville states—a fact which militates strongly against their being muscular fibre.

On the other hand, only one great objection can be brought against the first theory; that is, what can be the nature of a substance which is perfectly soft and flexible, and at the same time completely resists the solvent power of water, and which, although when first exuded is quite white, yet, in a short time generally becomes a golden brown, and, in some cases, black.

This, however, is the theory which I am inclined to believe to be the correct one. On removing one of the valves of a mussel, and carefully cutting away the soft portions of the animal, the foot, and byssus attached to a sort of flange at the back of the foot, will be seen, together with the powerful muscles which control their various motions. The foot is very small, with a groove running along its base, and serves merely to mould and give form to the byssal threads.

Having set out with the opinion that these threads are the

result of a secretion, now comes the question as to where the gland which secretes them is situated. About this there have been many diverse opinions. One man says it is at the back of the foot, between the pedal muscles. Another says that it is in the flange, which carries the byssus.

The latest opinion, and the one which such observations as I have made induces me to accept as correct, fixes its position as follows :—

If a portion of the integument of the foot be laid back on each side of the groove, it will be found that all that portion of the substance of the foot which surrounds the groove is glandular in its structure, and it is this glandular substance which is believed to secrete the peculiar substance of which the byssal threads are formed. The secretion exudes through a pore at the commencement of the groove, and running along it, is attached to the required spot by the foot, as before-mentioned.

Our next inquiry naturally is, what is the nature of the byssal secretion? When examined under the microscope, the byssal threads present little appearance of structure, being apparently simply hollow sheaths.

I have examined them chemically, and the results of the various re-agents employed would seem to show that they are similar in composition to Keratine, a substance found in horn, nail, and some other animal bodies. The reactions were, however, rather uncertain, so that I should not like to give a decided opinion as to their true nature.

LUNAR DETAILS. OCCULTATIONS.

BY THE REV. T. W. WEBB, A.M., F.R.A.S.

BEFORE we finally leave the *Mare Serenitatis* we must allude to a remark by Beer and Mädler, who observe that, except the *M. Crisium*, it seems to be the deepest, as, next to the *M. Frigoris*, it is the most reflective, of the plains in the N.W. quadrant; and that its interior contains no steep declivities anywhere, even in its craters, whence, in all likelihood, the difficulty of making them out, and the probability of the existence of more, among the luminous spots of this surface. The peaks, however, it may be remarked, on the ring of *Bessel* (INT. OBS. viii. 294), are not quite in accordance with this statement. As far as it goes, it would seem to indicate an unusual fluidity in the surface, at the period of its receiving its present form.

We shall now take the mountain mass of the *Caucasus* (16 in our Index Map), not so remarkable for its extent—which measures, according to Schröter, about 140, by 50 to 55 miles—as for its altitude. In this respect it rivals the neighbouring *Apennines*, and surpasses all other lunar elevations, except the ranges *Dörfel* and *Leibnitz*, near the S. pole; to which might be added, on Schröter's authority (confirmed by B. and M. themselves in the latter instance), the *Rook* and *D'Alembert* mountains, on the E. limb. On the W. side the *Caucasus* exhibits plateaus and valleys; on the E. it stretches along in an unbroken range, though of very unequal elevation, the great summits not forming ridges like the *Apennines*, but rising in insulated masses above the *Palus Nebularum*, as that part of the *M. Imbrium* is called which lies immediately at their feet. "Here we have in a small extent, and on a proportionally low base, a mountain mass of Alpine character towering up; the peaks raise themselves in steep *aiguilles*, and their shadow usually shows itself as a sharp line, scarcely any longer distinguishable, at its extreme end, from its slenderness;" the saddles, or *cols*, between them, are very deeply depressed. Towards the S. are numerous detached mountains, which, though less steep, are very sharp in their outlines, and have a noble appearance. The highest mass of the whole range lies just E. of the only considerable crater enclosed in it, *Calippus*; its loftiest peak (*Calippus α*) reaches the vast height of 18,600 feet, considerably surpassing our Mont Blanc—Schröter had given it 16,800 feet; another summit a little to the S. measures 13,300 feet. A headland a few miles further S, which projects into the *P. Nebularum*, rises to

8,700, and the last of the chain, where it sinks into the great strait between the *M. Serenitatis* and the *M. Imbrium*, to 9,100 feet; a magnificent termination to a superb range.* The passes on the E. side frequently do not exceed 2,600 feet; but some of the interior summits are very lofty, especially *Calippus* γ and δ, both a short distance N.W. of the crater so named, which are respectively 11,800 and 11,700 feet above the low country on that side.

Craters are either unusually rare in this region, or (as B. and M. think more probable) very small, and concealed by their position. Schröter has delineated a rather greater number; but a little experience will convince any careful observer that the shadows of an irregular surface under a low illumination are occasionally deceptive in form, and may require testing under other angles of incident light. Lohrmann, however, in his general map, also shows more than B. and M. But there is one regularly formed crater of considerable magnitude, and easily distinguishable, lying in the heart of the mountains, *Calippus*, already referred to. This is upwards of 17 miles in diameter; the interior wall has a sharp declivity of 50° or 60°, and its exterior slopes more rapidly than is generally the case; there are strong terraces towards the W., in which direction the depth of the bowl is 7,700 feet. Schröter, who thought he perceived traces of a central hill, gave the depth at least 9,800 feet. This observer speaks of the countless peaks, defying all representation, with which this region is studded, and has given a figure of the spires and obelisks of shade which the E. edge casts towards the terminator under the rising sun. The student, who will be well repaid by the grandeur of the sight, may look for them about the first quarter; but no exact time can be predicted, on account of the change produced by libration in longitude. With the opposite illumination of the lunar sunset, the effect is still beautiful, though not equally impressive; the same E. edge then appears, near the terminator, as an irregular bright streak, the comparative narrowness of which shows the rapidity of the slope on this side; and there would be little difficulty, from a combination of micrometrical measures of the breadth of the illuminated part with the heights given by B. and M., in obtaining a vertical section, or profile, in this direction, of some of these magnificent mountains.

Enclosed in the S. portion of the mass, Schröter has represented a depression, which cannot be satisfactorily identified on the maps of B. and M., or Lohrmann, but which is figured by the former observer as an elliptical wall lying N. and S., with a flat interior. This inner portion he found "neither

* Sch. gives 5,600 feet—probably for another point.

blackish, nor properly grey, but somewhat bluish," an observation worthy of the more attention, if the spot can be recovered, as being made with a reflector, in which there would be less liability to accidental colour than with an achromatic.

We next take the very interesting region of *Eudoxus* (17) and *Aristoteles* (18), with the chain of the *Alps* (19). This hilly district, lying between the *M. Serenitatis*, on the S., the *Lacus Somniorum* and (further N.) the *L. Mortis*, on the W., the *M. Frigoris* on the N., and extending to the first lunar meridian on the E., has a sharply defined contour under a high illumination, though its details are then but little distinguishable, and even *Eudoxus* and *Aristoteles* would be overlooked, excepting by those well acquainted with their position. At such times the whole region appears sprinkled with luminous dust; there must evidently be several thousands of these points, though it is impossible to perceive them separately. It seems scarcely practicable to get a correct design here. Our atmosphere is seldom clear enough to bring out the details distinctly, close to the terminator; nor can sufficient progress be made in a single night to enable the work of the next to be joined on to it; so that portions have to be drawn separately, and the whole design can only be completed after a long series of lunations. The greatest difficulty, however, lies in the overshadowing of the lower by the higher hills, till they are too far from the terminator to appear in distinct relief; for "it is nowhere upon the lunar surface permitted to infer, from luminous points, an elevation, or the contrary."

Eudoxus (17), is a noble ring, not measured by B. and M., but upwards of 50 miles* in diameter, according to Schröter, within which he could detect no trace whatever of any inequality, doubtless from having examined it at too great a distance from the terminator, as B. and M. found it full, in every part, of unevenness. This is an instance of the caution required in such investigations. The wall is doubled on the S.E. side by a narrow intervening gorge; its interior shows broad terraces and separate promontories. At the E. end it rises in one place to 9,800 feet; at the opposite to 11,300 feet, and two summits close together to 14,900 feet; our authors consider that these measurements do not possess any great degree of certainty; Schröter, however, has given the depth 12,600 feet, and observes, that the terrestrial Etna itself would stand in this great cavity without overtopping the wall.

On the N.E., beyond a high ridge, is an extent of about 1,270 square miles, occupied by upwards of 100 hills;—a chaos, in disentangling which B. and M. could not fully succeed, and

* This is probably somewhat in excess.

whose delineation, had it been possible, would have required a much larger scale.

Aristoteles (18), 51 miles in diameter,* is nearly as deep as *Eudoxus*, but its wall, though flattened in places, is much more rich in peaks, and attended on the inside by stronger and more connected parallel ridges, which can hardly be called "terraces," since they are almost everywhere, but especially on the W., divided by deep valleys from the main rampart. It is very inconspicuous in Full Moon, but in the N.E. part of the interior two dark spots may be perceived of only 2° reflective power. It does not seem to have been expressly remarked by B. and M., but it is certainly deserving of notice, that similar dark areas are not unfrequently met with in some parts of the interiors of large walled plains. We had a remarkable instance in *Atlas*, and others will come before us hereafter. The inner surface, though supposed by Schröter to be very even, from the deceptiveness of a high illumination, as in the case of *Eudoxus*, is really very irregular. Our authors observe that the interior of each of these great craters resembles the exterior, both as to the brightness and the character of the surface; an unusual circumstance, when great rings occur in mountainous districts. The wall of *Aristoteles* rises to 10,500 feet on the W., 10,700 feet on the E. side. To the W. lies a smaller, but equally deep crater (a), like a reduced copy of it, which, as Schröter observes, offers an exception in not encroaching upon the outline of its gigantic neighbour. It may be a question whether this is any proof of contemporaneous origin.

But what distinguishes *Aristoteles* from all other lunar rings are the rows of hills which take their departure from it in three definite directions, N.E., N.W., and S.W. Similar rows, indeed (not to be confounded with mere luminous streaks), issue from very many rings: for instance, *Aristillus*, which will shortly come under our notice; but they nowhere appear equally numerous, and at the same time so regularly linear and parallel, as here. Their directions, too, are at right angles to each other, and the axes of the three systems intersect in the centre of the great crater—more than enough, as B. and M. justly remark, to convince us that no product of mere chance here lies before the eye. Moreover, we see here, as it were in miniature, the type of the directions of almost all the great mountain chains of the moon; and the region of *Aristoteles* is a model on a small scale, illustrating the great whole. This crater is the centre of the working forces, which appear, like those of crystallization, to have exerted themselves solely in the specified directions, and not at any intermediate

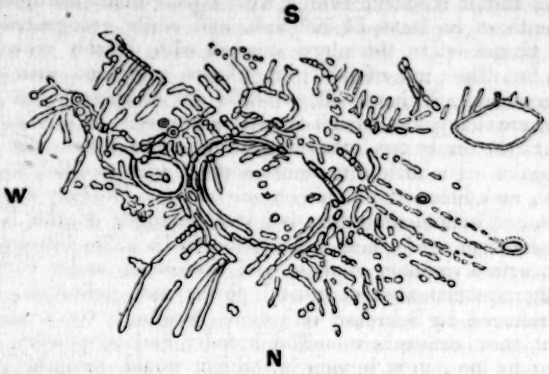
* 57½, according to Schr., keeping due proportion with *Eudoxus*.

angle. The same directions may be distinguished, though less evidently, around *Eudoxus*. "Here is a wide field for investigation; and if it should ever come to pass that this selenogenetic hieroglyphic could be explained, an important advance would be gained in the physical knowledge of the heavenly bodies." The individual hills themselves are extremely minute; many, if insulated, would pass unnoticed, and the greater part may still have escaped discovery. The rows on the N.E. are in general the longest, and the hills most separated: there is little difference in their relative elevation—at least, no uniform diminution in any certain direction is perceptible. Their general base is a slightly inclined table-land, and the valleys between these rows or chains ascend very gradually, with a gradient of about $\frac{1}{100}$, towards *Aristoteles*. The two other systems are composed of shorter and more connected rows, that rapidly decrease in relative height. Not a single point in these chains is remarkable for reflective power; and they would be sought in vain in the full moon, or even at a distance of more than 12° or 15° from the terminator. On the whole, these systems can be observed but seldom, and never all at the same time; and our authors would not recommend any one, even with the aid of the best instruments, to begin his lunar studies with such objects. The best opportunity for their observation is in the increasing moon of March and April and the wane of October.

Schröter missed these singular configurations, and unfortunately they are not included in Lohrmann's "Sections;" they appear in his general Map, but with less regularity than in that of B. and M. I have seen them on several occasions, not far from the first quarter. In one instance I have noted that the interior of *Aristoteles* was less, and that of *Eudoxus* more than half covered with shadow, which may serve as an approximate guide to the suitable time for observation. The accompanying illustration, taken from the Map of B. and M., will give some idea of what ought to be looked for. The curious district to the S.W., where five or six low ridges run at right angles into a higher one, is separately described by B. and M. as belonging to another region; but its peculiar arrangement seems to connect it with the neighbouring formations.

Immediately S.W. of *Eudoxus* lies a table-land ending towards the S. in a point marked Δ. "But who could undertake," say our authorities, "to count the number of the hills that lie on the S. and S.W. of *Eudoxus*, and from the abovementioned plateau near Δ towards the *M. Serenitatis?* The mountains crowd themselves here like the stars of the Milky Way in its densest parts, so that a correct portrait of them in

detail seems to belong to the impossibilities." This region stretches out towards the S.W. in the direction of *Posidonius*,



terminating in a steep high mountain, *Posidonius* E. (the *Promontorium Hippolai* of Hevel); on the E. it joins the *Caucasus*, and merges in a dusky plain between *Calippus* and *Eudoxus*.

Nearly E. of *Eudoxus*, and N. of *Calippus*, a mountain-ridge running in the meridian distinguishes itself by its brilliancy (7°) in the full moon. It rises to a height of nearly 7,400 feet. Schröter has made it 10,200.

S.S.E. of *Aristoteles* lies a curious rampart (somewhat like a camp), included in the above diagram, and called *Egede*. The wall is extremely narrow, but pretty steep within, and rises only about 380 feet above the surface on either hand. Its form is somewhat quadrangular, and the bearings of its sides correspond with those of the chains of hills round *Aristoteles*. It is an easy object near the terminator, but disappears under higher illumination. Schröter, who had overlooked it during his observations of eight years, was disposed to think some artificial change, such as would arise from cultivation, might have made the grey tint of its interior more conspicuous.

Further E. we come to one of the greatest curiosities of the lunar surface, the *Wedge-shaped Valley of the Alps*, shown in our Index-Map just beneath the figure 19. The existence of this object seems to have been indicated in Cassini's Map,* but it was carefully observed and delineated for the first time by Bianchini at Rome, with a refracting telescope of about 102 feet, the work of Campani, who was the most celebrated maker

* That is, according to Bianchini. Schröter says that he missed it.

of the day. It is a colossal ravine, 83 miles long, and 5¾ to 3½ miles wide, which cleaves in a direct line a mass of wild and steep mountain scenery, sinking with extraordinary abruptness to a depth of at least 11,500 feet, and easily recognized in every phasis. Its sides are crested with densely crowded peaks, but these are of little importance compared with the precipices beneath them. These cliffs are steepest at the E. end, where it breaks through the loftiest masses of the *Alps*; and here it sends out several lateral valleys which insulate their peaks. Its bottom contains some ridges parallel to its length; and Schröter noticed on one occasion two very minute craters, one within, the other without, the edge, on the N.E. side; the former of which appears also in L. The infrequent and uncertain visibility of objects of this class, under corresponding circumstances of optical power and definition, has been referred by Schröter with some plausibility to variations in the lunar atmosphere. The broader end terminates, according to him, in a semicircle, which would resemble the glorious Cirque de Gavarnie, in the Pyrenees; but B. and M., and Lohrm., carry it on as a contracted gorge. There is, however, a sufficient want of accordance between their representations to make it an eligible undertaking for amateurs possessed of adequate instruments to plan out its marvellous details with all attainable minuteness. The task would be one of no small interest. They would have before them features unparalleled, probably, upon the earth. Imagine a precipitous gulf extending for more than 80 miles; in whose greatest depth the pride of the Pyrenees or Apennines would disappear!

Between this enormous cleft, *Egede*, and the grey levels of the *P. Nebularum* to the S., is a large tract of hilly ground, of extremely difficult delineation. Schröter perceived here about fifty separate summits; B. and M. estimate their number, with a good aperture and power of 160, at least 700 or 800.* These have no communication with the hilly region already mentioned as lying N.E. of *Eudoxus*. I have repeatedly viewed this curious district with wonder, both before and after the quadrature; on one occasion it struck me as resembling a quantity of minute pellets of garden mould spread out over a gently sloping surface.

Further E. the ground begins to rise into the true base of the *Alps*, and becomes crowded with considerable ridges and depressed rows of hills, with intervening valleys, leaving

* A little closer examination of their predecessor would have reduced the extent of their intimated superiority. Schröter counted 48 or 50 with a power of 112 in a 4-inch achromatic; saw more with 226; and in his 27-ft. reflector expressly calls them innumerable.

only a narrow width for that lofty chain. On the other side of the wedge-shaped valley the landscape maintains a similar character, presenting high, steep mountains, with no regularity and little connexion, surrounded by lower elevations on a base sinking towards the N. into the *M. Frigoris.* It forms the W. end of the most extensive hill-district of this kind in the whole visible lunar surface, stretching away under various modifications into the next quadrant beyond the *Sinus Iridum*, with a length of at least 920, and a breadth varying from 90 to 230 miles.

The *Alps*, properly so called (19 in our map), are the lofty E. and N. edge of the W. portion of this region, extending about 156 miles, as far as the great wall-plain *Plato* (38). They rise with an abruptness inferior to that of no lunar mountains, out of the low dark plain of the *M. Imbrium*, with which their bright summits form a contrast easily recognized under every illumination; but though their internal structure is the same with that of the *Caucasus*, they do not attain an equal height with it or with the lunar *Apennines*. The lover of appropriate nomenclature may on this account regret the misplacing of the names of the last-mentioned range and the *Alps*; but had Hevel been fully acquainted with the comparative altitude of the European chains (and there is no reason to infer his ignorance in this respect), he would not, as B. and M. suggest, have reversed these appellations, as his system was based wholly upon a fancied correspondence in position of the principal features of the earth and moon. A peak, called by B. and M. *Cassini* η, begins the range on the S., rising like a bright white tower from the dusky *P. Nebularum*, which encompasses it nearly on every side. Its height is 7,600 feet (7,100 Schröter), but little short of the magnificent Niesen, which so many Swiss tourists will call to mind as overlooking all the picturesque Lake of Thun. The second, *Cassini* z, is a similar peak, forming, with two others, a beautiful triangle, which glitters far off in the lunar night, and casts long shadows from the risen sun. It reaches 8,500 feet (nearly 7,000, Schröter)—more than the Breven near Chamouni. The next in order is not so lofty, and a spur runs off here into the plain. But before we reach the end of the *wedge* we encounter a great mass, combining several summits of various forms, to which Schröter gave the name of *Mont Blanc*, and which lies in a latitude almost exactly corresponding with that of its European namesake. He gave it, from a mean of three measures, 14,000 feet; B. and M. only 11,900 feet. Even if we adopt the smaller value, the aspect of this giant from the outstretched level beneath must be more imposing than that of

our Mont Blanc, at 15,784 feet, among a host of minor elevations. Midway between the great valley and the S. edge of *Plato*, where the general height declines, one bright summit, *Plato* λ, attains 12,000 feet; Schröter gives but 8,600 feet, probably from the shadow then terminating in elevated ground. He assigns to a peak in the interior, between λ and the narrow end of the *wedge*, a height of 10,200 feet above the vicinity; in accordance with the remark of B. and M. that the base of these mountains, like that of the *Caucasus*, reaches but a small proportion, hardly one-third, of the altitude of the peaks which they sustain. I have noticed, with Schröter, the grand spires of shade which these mountains cast after their sunrise. With an opposite illumination their aspect is like that of the *Caucasus*, a brightly illuminated but narrow border to the *M. Imbrium*.

OCCULTATIONS.

Feb. 23rd, 130 *Tauri*, 6 mag., 5h. 31m. to 6h. 24m.—26th, A^1 *Cancri*, 6 mag., 9h. 51m. to 11h. 7m.—27th, *h Leonis*, 6 mag., 7h. 48m. to 9h.—28th, B. A. C. 3529, 6 mag., 6h. 57m. to 7h. 46m.

COMETS.

OBJECTS RECORDED AS NEBULÆ, BUT NOW SUSPECTED TO HAVE BEEN COMETS.

BY G. F. CHAMBERS.

(*Continued from Page* 380, vol. viii.)

The following are cited from Sir J. Herschel's great Catalogue of Nebulæ, published in the *Philosophical Transactions* for 1864. I have not yet been able to recover the original dates of three out of the four:—

No. 614. R. A. for 1860, 2h. 44m. 6s.; Decl. +36° 55′·7. Observed by Bessel. Looked for and not found by D'Arrest, who supposes it to have been a comet.

No. 2094. R. A. for 1860, 10h. 17m. 5s.; Decl. +27° 43′·9. Observed by Sir J. Herschel. Looked for six times by Lord Rosse, and not found; "this, then, was a comet or lost nebula."

50 ♅ III. On March 19, 1784, Sir W. Herschel observed an exceedingly faint nebula 3m. 15s. following the star 45 Canum, and 4m. S. Sir J. Herschel states that he has found

a memorandum that this nebula is lost, and was probably a comet.

No. 3550. R. A. for 1860, 13h. 21m. 13s.; Decl. +6° 43′·4. Observed by D'Arrest, but not found again, on February 19, 1863. Sky perfectly clear. "Perhaps a comet."

As the catalogue is now completed, probably the reader would not be indisposed to peruse a summary of it and the former catalogue, published in *Recreative Science*. The results have been, in all cases, brought up to the present year.

Altogether 796 comets have passed under review; this, then, represents the total number of comets placed on record, by the historians in early times, and by the regular astronomers subsequently. As some uncertainty attaches to many of the early comets, in consequence of the incomplete or vague character of the language employed to describe them, we may say that in round numbers about 800 comets are known to have passed through our system. Of these, 291 have been subjected to calculation, by which (except in a few cases) we have been made fully acquainted with the size and character of their courses through space, or, in technical phrase, with the *elements of their orbits*. The orbits of comets are of three kinds, each a section of a cone.

If a cone be cut parallel to its base, the section will be a circle. No comets revolve in an orbit, thus obtained, but the orbits of most of the planets are very nearly true circles. If one cone be cut diagonally, the section will be an ellipse. This is the curve in which nearly all the planets and such comets as are *periodical* revolve. Again, if the cone be cut in a direction parallel to one of its faces, the section will be a parabola. Finally, if the direction of the section be still further inclined over, the resulting outline will be that of a hyperbola. Whilst a considerable number of comets are known to follow elliptic paths, most of the residue have traversed parabolic paths. The known hyperbolic comets amount only to five in all.

The reader may obtain a very sufficient idea of these matters by actually operating for himself on a real cone of soap; in this way he will find that as the parabolic and hyperbolic curves have no end, or, as the mathematician calls it, are of *infinite* length, comets, following such curves, pass once only through the solar system, and thence away, we know not whither.

The following is a brief abstract of the 291 calculated comets:—

Known to revolve in elliptic orbits .	19
Subsequent returns	54
Elliptic comets not yet verified . .	37
Parabolic comets	176
Hyperbolic comets	5
	291

A careful analysis of the motions of the calculated comets has enabled me to make the following general deduction:—That with comets revolving in elliptic orbits, there is a strong and decided tendency to direct motion, that is to say, motion in the order of the signs of the zodiac. The same obtains with the hyperbolic comets. With the parabolic comets there is, however, a rather large preponderance the other way; but taking all the calculated comets together, the numbers are too nearly equal to afford an indication of the existence of any general law governing the direction of motion.

Similarly analysing the inclination of the orbits, I have found that there is a decided tendency in periodic comets to revolve in orbits but little inclined to the elliptic, and that, therefore, a low inclination (especially if combined with direct motion) is an eminently favourable indication of an unrecognised comet being a periodic one. Uniting all the cometary orbits, I find that there is a tendency to congregate in and near a plane inclined 50° to the ecliptic.

An examination of the positions where comets approach nearest the sun and cross the ecliptic, shows that, as regards the former, there is an evident tendency to crowd together in two opposite regions of the ecliptic, between 60°—120°, and 240°—300°, reckoned from the first point of Aries. Then as regards the ascending nodes (or places of crossing the ecliptic), there is a tendency in these also to congregate in two, though not exactly opposite, regions, viz.: 30°—90°, and 180°—240°.

The general proposition that comets vary much in the nearness of their approach to the sun, will be best understood by an inspection of the following table:—

PERIHELION DISTANCES.

	Comets.
Within a radius of 95,000,000 miles from the sun	177
Between 95,000,000 and 190,000,000	55
„ 190,000,000 and 285,000,000	4
„ 285,000,000 and 380,000,000	0
„ 380,000,000 and 475,000,000	1
Beyond 475,000,000	0
	237

Finally, as regards the season of the year most fruitful in comets, of 290 known perihelion passages there occurred in—

January	24
February	22
March	23
April	25
May	20
June	24
July	19
August	18
September	32
October	27
November	31
December	25
	290

The monthly average is, therefore, 24·2. April, September, October, November, and December are above the mean; the other months are below. The minimum is August, which only exhibits 15, or 40 per cent. below the average; a circumstance, doubtless, due to the long days and short nights, which more or less prevail during the summer months. The quick rise in September, when the maximum is reached, is probably due less to the lengthening of the nights (and consequently increased opportunites for observation) than to the excellence of that month for astronomical purposes. The advantages afforded by the long winter nights are perceptible, though often partially neutralized by the frequent inclement weather. I had proposed to extend this analysis to the uncalculated comets, making use of the dates of discovery as the basis upon which to proceed; but the uncertainty and contradiction occurring in the majority of the accounts has hitherto deterred me, fearing that deductions sufficiently interesting to repay the trouble might not be arrived at.

PROGRESS OF INVENTION.

PETROLEUM.—Perhaps nothing more wonderful is found in the history of commerce than the vast trade in petroleum, which has grown up so suddenly. The use of this valuable substance, especially for domestic purposes, is still attended with very serious inconveniences—the danger of explosion, and the more or less disagreeable odour which is evolved. The former is reduced to a minimum by care in the preparation of the commercial product; the latter has, in a great degree, baffled hitherto all the efforts of ingenuity and science. But even this objection to the use of petroleum is likely now to be obviated, and by very simple means. The disagreeable odour is produced by a highly volatile vapour. Ordinary distillation is incapable of separating it effectually, and chemical reagents produce but imperfect effects upon it; but the application of a principle which has been found so valuable and effective in many other branches of manufacture has been sufficient to remove the difficulty. The petroleum is merely raised to the temperature of about 135° Fahr.; and then, the pressure of the atmosphere having been partially removed by an air-pump, is kept agitated for some time, after which it is washed with cold water. The slight increase of temperature and the partial vacuum cause the compound to which the odour is due to pass off as a gas; and the result is, in many instances, so free from smell, that it might be mistaken for the best vegetable oil. The removal of the highly volatile vapour increases the density of the product, and renders its use in lamps less dangerous. Naphtha—and no doubt many other fluids which emit disagreeable odours—may be purified in the same way.

VALUABLE APPLICATIONS OF MAGNESIA.—The researches of M. Sainte-Claire Deville regarding the hydrate of magnesia have led to the production of a very beautiful and useful substance, which has all the good qualities of marble, and, in addition, may be cast in moulds so as to form busts, etc., like ordinary plaster. The hydrate is obtained by calcining the chloride or nitrate at a red heat, and sets very soon on the addition of water without losing its good qualities. It may be mixed with pounded marble, for the purpose of giving it a peculiar grain and colour. Kept for some months in a stream of water, it becomes so hard, as to be capable of scratching marble; it assumes the crystalline form, and a thin plate of it possesses the transparency of alabaster. Dolomite, and some other combinations of magnesia, when calcined in the same way, afford an excellent cement, which sets under water, and becomes exceedingly hard and tenacious. The temperature during calcination must not, however, exceed from 300° to 400° Cent., which is below redness, or caustic lime will be set free, and the product will be of little or no value; if it has been raised to a white heat, it will not set at all. It is indispensable to the goodness of the artificial marble, or cement, that any lime associated with the hydrate of magnesia should be in the form of carbonate. The

value of any magnesian compound, as a source of artificial marble, or hydraulic cement, depends on the proportion of magnesia contained in it. Rocks having 61 per cent. carbonate of magnesia answer well for cement, those having 55 per cent. for hydraulic lime, while those having 16 per cent. will still be suitable for stucco.

STEAM WITHOUT A BOILER.—The great inconvenience and loss of heat which arises from the necessity of keeping at a high temperature the large quantity of water required in the ordinary steam boiler, has naturally caused at all times a great desire to invent some plan by means of which this serious waste of fuel might be avoided; but hitherto every effort in this direction has been vain. The boiler must contain a large quantity of water, or too violent a change of temperature would be produced by the supply of feed-water, not to mention the danger of explosion, which might arise from lessening the water space. An ingenious, though not altogether novel, contrivance has been devised to economize fuel, without giving rise to the inconvenience and danger which must be consequent on a diminution of size in the ordinary boiler. A tube communicating with the water supply passes down through the top and nearly to the bottom of a very strong spherical generator made of iron, under which is an ordinary furnace. The small quantity of water first injected through the feed-pipe, and scattered over the interior of the sphere by the perforated nozzle at its extremity, is immediately changed into steam which at once becomes highly superheated. The quantities subsequently and successively thrown in, to meet the requirements of the engine, are vaporized by the superheated steam before ever they come in contact with the interior walls of the generator. With this contrivance, no water is kept in the state of ebullition, and the size of the apparatus is regulated only by the necessity for making the steam-space large enough to prevent undue variations of pressure. Nevertheless, it is exposed to certain inconveniences, the chief of which is, however, the danger of explosion from overheating, or from a badly-regulated supply of water; but the principle appears a sound one, and is well worthy of a careful trial, which may perhaps suggest improvements calculated to remove every objection.

NEW TEST FOR CANE AND GRAPE SUGAR.—The greater value of cane, compared with that of grape sugar, has always caused a strong temptation to adulterate the former with the latter, to the very great inconvenience and loss of the consumer, who is thus made to pay for a cheap and comparatively worthless article the price of a superior one. Hitherto the adulteration could not be easily detected by ordinary persons; but it has been ascertained that bichloride of carbon, added to cane sugar, and kept for some time at the boiling point of water, gradually produces in it brown spots, which, by enlarging, ultimately cause the sugar to be of a more or less intense black; while, under the same circumstances, no change is produced in the grape sugar. Chlorine which is liberated from the bichloride, forms hydrochloric acid that darkens the cane sugar, but has no effect on the grape sugar, which is not so easily affected by acids. It must, however, be borne in mind that what is

said is true only of hydrochloric acid in the gaseous state, since, as a concentrated solution, it would blacken even grape sugar.

Colours produced by Photography.—Among the very earliest efforts of the photographer was the reproduction of the natural colours of objects; but although these were obtained, by accident, with more or less of truth, their certain, or even frequent, production was for a long time beyond the power of his art. So long ago as 1848 some progress was, however, made towards the attainment of this so much desired object, and a mode of reproducing colours on silver plates, and rendering them to some extent permanent, was invented; but little or no advance has taken place for some time past. Very recently another step has been gained, and the natural tints may now be obtained on paper, though not as yet with the permanency that is to be desired. The colours produced on the silver plate are due to the violet subchloride of silver. In ordinary circumstances, this compound is very ineffective with paper; but it has been found by M. Poitevin that the action of light upon it is rendered far more energetic by means of substances such as the alkaline bichromates, chromic acid, and nitrate of uranium, which are themselves affected by light. Those bodies which, while they afford chlorine, oxygen, etc., do not combine with chlorine, answer well for the purpose. The process used with the paper is a very simple one; it is covered with the subchloride of silver, by allowing light to act on the white chloride in presence of a reducing salt, is then washed with a mixture containing one volume of a saturated solution of bichromate of potash, one volume of a saturated solution of sulphate of copper, and one volume of a solution containing five per cent. chloride of potassium, and is then allowed to dry. Paper so prepared will remain fit for use for several days, but must of course be preserved from all access of light. It may be employed in an apparatus for enlarging photographs, but not in the camera: the rays of light being transmitted through a transparent coloured design for from five to ten minutes. The picture is fixed by washing in water that has been acidulated with chromic acid, next treating with water containing bichloride of mercury, and afterwards washing, first with water charged with nitrate of lead, and then with distilled water. But it must be kept not only from the direct rays of the sun, in which it would very soon become brown, but even from diffused light, by which also it would rapidly be destroyed. It must be admitted that the colours as yet obtained by this process are not so vivid, nor some of them so decided, as with the silver plate. With regard to the fluid with which the paper coated with violet subchloride is washed, M. Poitevin thinks that the sulphate of copper facilitates the reaction, that the chloride of potassium preserves the whites which are formed, and that the bichromate acts on the subchloride of silver. M. Becquerel, however, believes that the bichloride acts, not on the insulated subchloride, but on the sensitive coating of the paper.

Induction Electrical Machine.—A new, ingenious, and highly effective electrical machine has been constructed on the principle of the electrophorus, by Mr. Holtz, of Berlin. It consists of a cir-

cular plate of glass, 40 centimetres in diameter, capable of revolving, by means of a handle, on a horizontal axis. Parallel to this disc, and at the distance of 3 or 4 millimetres from it, is fixed another disc 45 centimetres in diameter, and having two deep grooves 11 centimetres wide. Beside each groove, at both sides of the disc, is a paper armature, which does not reach so near the circumference of the fixed disc as to extend beyond that of the moveable. The interior armatures are 25 millimetres wide, and the exterior 54. Each of the interior has two teeth which project into the adjacent groove. In front of the moveable disc are rods having at the end next the disc metallic combs, the teeth of which are 13 millimetres long, and at the other end wires connecting them with a conductor. When the apparatus is to be used, one of the armatures is touched with a plate of hardened caoutchouc, which has been electrified by rubbing with a catskin, or bringing it in contact with some other electrified body—the moveable disc being at the same time kept revolving. As the different portions of the revolving disc pass in front of the electrified armature, they become oppositely electrified, giving electricity to the points of the comb, and then when released from the inductive action of the first armature to the teeth of the next armature. The armatures are thus kept constantly excited, and the opposite electricities produced successively on succeeding portions of the revolving plate, are carried to where they are to be applied by appropriate conductors. The sparks afforded by this machine are from three to ten centimetres in length: and the current is capable of producing stratified light with Geissler tubes, deflecting the needle of the galvanometer, and even without a Leyden jar, giving a continuous and very perceptible shock. Hitherto the principle of the electrophorus has not been utilized further than for the production of an electric spark, to be employed in the explosion of mixed gases during laboratory experiments. It has been observed with this apparatus that the change of motion into electricity gives rise to a sensible retardation, similar to that produced by friction with the ordinary machine.

Desulphuration of Coal Gas.—A further and most important utilization of the ammoniacal liquor of gas works is likely to lead to very important results—the complete purification of illuminating gas from the sulphur, which is ordinarily so disagreeable and mischievous a constituent of it. No complicate machinery nor troublesome process is required for the attainment of this very desirable object. The gas is merely brought thoroughly in contact with some of the ammoniacal liquor, which is an almost valueless product of the gas-works itself; and, when proper care has been taken, the whole of the sulphur is removed, not only without injury to the gas, but with a considerable augmentation of its illuminating power.

New Principle of Ventilation.—An experiment recently made by M. Galibert illustrates a principle which there is reason to believe may be effectively applied to the purposes of ventilation; namely, the power possessed by compressed air of determining the entrance into an inclosed space of a very large quantity of air from without. He

used, for illustration, one of the bags employed with his respiratory apparatus, holding about 120 litres, and having an aperture in its upper part 10 centimetres wide. Keeping the aperture open, he continued for four or five seconds to project into it air compressed by the mouth and lips; after which, on closing the aperture, the bag, though perfectly empty previously, was found to be one-third full of air; and it was completely filled by repeating the operation twice, though all the air introduced from the mouth did not exceed three-fourths of a litre, that is, the one hundred and sixtieth of what had entered.

Unalterable Photographs.—The only mode hitherto known of producing unalterable photographs has been by vitrification. M. Penabert, however, recently exhibited to the Academy of Sciences some which, though not vitrified, are so indestructible that it is impossible to remove them from the glass, so as to render it capable of being used a second time. The opaline glass employed in the process having been well cleaned, is to be coated with ordinary collodion that is at least a year old; it is then to be plunged for a few minutes in a sensitizing bath, which contains 7 grammes nitrate of silver to 100 grammes distilled water, and 16 grammes pure nitric acid to 1000 grammes of the silver solution, and afterwards to be exposed for about fifty seconds in the camera. The developing fluid consists of a solution of photosulphate of iron, containing two-thirds more water than that ordinarily used, and one-fifth pyroligneous acid. The picture thus obtained, which is a positive, is fixed by a weak solution of hyposulphate of soda, and is intensified by a very weak bath of sulphuret of ammonium.

Miscellaneous.——*Test for Gum Arabic and Dextrine.*—If white of egg is decomposed with a small quantity of sulphuric acid, dilute hydrocyanic acid, or an organic acid, and a liquid containing dextrine is poured into the turbid fluid thus produced, a precipitate will continue to be formed, even after enough dextrine solution to throw down all the albumen has been added. If a solution of gum arabic is used instead of dextrine, not only will no precipitate be formed after the albumen has been thrown down, but the precipitated albumen will be redissolved. When the solution which has thus become clear is heated, it is rendered turbid.——*New Saw for Stone.*—Stone is now sawn in France with great rapidity and economy, by means of a perforated disc of iron on which a coating of lead has been cast, the perforations serving to connect and bind the plates of lead thus formed at the two sides of the disc. The lead is kept well covered with emery, which falls on it from a reservoir above, the excess being received in a vessel below. A saw of this kind, 1·10 metres in diameter, driven by a four-horse engine, was found to move through marble at the rate of 8 centimetres per minute, and through granite at the rate of 25 millimetres in the same time.——*New Cement.*—A cement, capable of uniting into a solid mass stones, pebbles, etc., so as to form artificial pudding-stone, conglomerates, etc., of extraordinary strength and tenacity, impervious to moisture, and capable of being moulded into statues, bas reliefs, etc., may be made by finely

triturating iron sponge, and mixing it with sand, which has been moistened with slightly acidulated water. The iron is oxidised at the expense of the water: and the silex forms with the oxide, silicate of iron, which possesses a very great tenacity, and is not affected by atmospheric changes, nor even by acid or alkaline liquids at a boiling temperature.——*Consumption of Smoke.*—The French Government some time since issued a very stringent ordinance regarding the consumption of smoke in factories, which would very shortly come into effect. A number of manufacturers of Lille asked that its becoming law should be put off for some time, in consequence, as they said, of no means being yet known for consuming the smoke, to the extent required. The Minister of Agriculture, Commerce, and Public Works granted their request, and stated, at the same time, that the object of the ordinance was already sufficiently attained, on account of the precautions which had been adopted; and that it was enough, without employing a special apparatus, if the fuel were merely introduced by moderate portions at a time into the anterior portion of the furnace, so that the gases evolved by the heat may pass over the fuel already in a state of intense ignition, and thus be consumed.——*Effect of Temperature on Electro-motive Force.*—It was found by Becquerel that the electro-motive energy of a galvanic couple with two liquids is increased by elevation of temperature. A change from 0° to 100° C. caused the effect to be augmented to the extent of 0·04 of its value. This is not due to the decrease of the resistance, which is rendered three times less than before, but to increase of intensity in the chemical action. M. Lindig, in pursuing the same investigation, has ascertained that the effect of heat is not always the same. Thus, for example, it increases the electro-motive energy with non-amalgamated zinc and sulphate, or chloride, of zinc; but diminishes it with amalgamated zinc and the same fluids. In point of fact, the electro-motive energy will be increased only when the action of the dissolving fluid on the metal, and the action of the two fluids on each other are augmented.

ARCHÆOLOGIA.

The remarks we made on the early tumuli opened near Malton in Yorkshire, in the Intellectual Observer for the month of November, have provoked a very unnecessarily angry paragraph in the *Malton Messenger*. It is rather to be regretted that writers in country papers, on anything like literature or science, seem to think it necessary to spice their articles with something in the shape of abusiveness, and they are apt, under this feeling, to conjure up supposed authors of articles in reviews, in order to have a person to attack rather than an argument. We suppose the mere object of this is to make the circle of readers thus addressed believe that the writer, who is unknown, is a wiser man than some other individual he chooses to name, who happens to

be better known, and therefore we will take no further notice of the particular tone of the paragraph to which we allude; but perhaps it may not be unacceptable to our readers if we give a little further explanation of the subject in question, and we regret that we are obliged to do it very briefly. We will only observe, with regard to the paragraph itself, that its author has not, as he seems to suppose, corrected us, but has only given us more distinct information on one point—the *cowrie* shells found in the tumulus near Malton are not Oriental, but are such as are to be met with on the coast of Yorkshire. This does not materially affect the question. We have stated that Oriental cowries are found in the Anglo-Saxon graves in the south, but these shells must have been extremely rare; and the sentiments which caused them to be buried with the dead very probably extended to any other cowrie shells within reach of the Teutonic population of the north.

With regard, however, to what our irate friend calls "an Anglian period"—we do not recollect having seen the term before—we have only to remark that he, in common with many others, seems to have a very misty notion of the state of Britain under the Romans. Roman civilization extended to a certain distance round the Roman towns, and to a smaller distance, perhaps to a very small distance indeed, round stations on the roads and villas. There was a population, no doubt, which was not absolutely broken into Roman manners and feelings, simply because the Romans did not think it worth while to break them. These, probably, inhabited those numerous and curious sites, spread over our island, which are commonly known as British villages, in which have been found not only Roman coins dating from the latest period of the imperial rule in Britain, but even the rude coins of the period which immediately followed. Now, during this rather long period, this population did no doubt bury its dead, and some among them, their people of higher consideration, must have been buried in such a manner that we may expect to find traces of their interments. Again, there can be no doubt, from historic evidence, that the Roman population of Britain began comparatively early in the Roman period to be recruited chiefly from the Teutonic race, and, in some degree, from Gaul. Now the Teutonic race, even after they had accepted the forms of religious belief and worship of another race, were exceedingly tenacious of their old forms of burial, which is proved by the circumstance that, during at least two or three centuries after their conversion to Christianity, it was almost impossible to restrain them from burying their dead in the old cemeteries of their Pagan forefathers, with the old Pagan ceremonies. It was in the struggle to prevent these practices that our churchyards originated. The clergy laboured to make people believe that there was no chance of salvation unless they were buried within reach of the immediate protection of the walls of the church. We have, therefore, every reason for believing that the Teutonic element in the population of Britain buried their dead in their own national forms during the later part of the Roman period, and a long period which followed it; and these interments were no doubt then of a

much ruder form than when we find them more distinctly characterized, at a time when the Angles and Saxons had gone through a great movement of social progress. The Anglo-Saxon cemeteries, which are undoubtedly Anglo-Saxon (there are distinctly Anglo-Saxon interments in tumuli, which are probably older), appear to date not farther back than the sixth century, leaving thus the whole Roman period, and a full century afterwards, unaccounted for for tumuli which were not Roman. Does our learned friend of the Durham press suppose, that, during the long period of Roman rule, and subsequent rule or no rule, nobody but Romans buried their dead, and, if this be not his opinion, can he tell us what has become of all their burial places? From the manner in which he looks upon the subject, we may suppose he imagines that the moment the Romans came here they stopped everybody but themselves from burying their dead, and that none but Romans were buried during the next five centuries, until the Saxons established their cemeteries here! It is not more than thirty years ago that antiquaries of the class of those to whom we are now more especially addressing ourselves, insisted that all those cemeteries which nobody now doubts to be Saxon, were "ancient British." Why should not some other antiquaries of the present day be labouring under the same delusion with regard to another less definite class of interments, about which, according to their own account, they seem to know nothing?

There is only one other point of which we will take any notice—the notion that an Anglo-Saxon lord or lady would be buried in the tumulus of an ancient Briton, buried 2000 years (this number of course exists in the imagination of the newspaper writer) before the Anglo-Saxon period. It is a notion which only shows, on the part of our friend and critic, a want of knowledge which we will try to supply. The Teutonic peoples, and probably the other barbaric peoples of the west, believed that the graves of the dead were a sort of earthly habitation of their spirits, which haunted them at will, and, when absent, left very dangerous guardians, dragons which vomited fire, and even worse monsters than those in charge. It was in this feeling that the circles of stones or the ditches were made round the tumuli, in order to mark very distinctly the limits of the sanctity of the tomb, which it was dangerous to transgress. An Anglo-Saxon would never be buried within the sacred precinct of the grave of a people whom he did not know, and who might be hostile to his race, and especially if they had lived 2000 years before his time. It would be putting his spirit under a state of everlasting hostility and persecution from an unknown spirit which previously occupied the place; a spirit which, in Anglo-Saxon notions, would be considered as an evil spirit. It would be about the same thing as if, in the mediæval "ages of faith," a member of a very pious family, on the death of his kinsman, went to the priest and asked him to intercede with St. Peter to send his beloved relative to the devil. There are known two or three exceptional cases—of great rarity—where an Anglo-Saxon interment was made in an older barrow, which people hastily called British. They have only been called

British by the sort of negative evidence that nothing was found in them which was either British or not British. But what we have just stated will furnish a good reason for believing that the Anglo-Saxon interment itself was a proof that the earlier interment was not one of 2000 years before. The intermingling of the Anglo-Saxons with the older population is explained without difficulty. Laying aside the much earlier Teutonic colonies on the eastern, and probably even the southern coast, the Belgic, the earlier absolutely known colonist element of the population of this island came in with the Roman military recruitments, and were amalgamated with the population of the Roman towns, which no doubt became more and more Teutonic towards the fall of the Western Empire. This mixed population existed long after the fall of the Roman power, and, in the early Anglo-Saxon cemeteries in the neighbourhood of the old Roman towns, we find graves in which an individual has been buried in all the religious forms and with all the accessories of a Roman burial. This leads to a question which would require more space than we can now give to discuss. The races were, in the towns, so entirely amalgamated, that there was no personal enmity in this world, and none was suspected in the next. Nevertheless there is no instance of a Roman interment in an Anglo-Saxon grave or of the reverse. At a distance from the towns the case was somewhat different; the amalgamation of races was less. There can be no doubt that towards the end of the Roman period there was a continually increasing influx of a Teutonic population, who came in for other than military purposes, and who no doubt lived here as a Teutonic people. This was especially the case in the north, where there is reason for believing that the Angles had settled long before the establishment of the Saxons in the south. We have reason, therefore, to suppose that very early barrows, in which the objects found point to no very certain period, may have belonged to a Teutonic population in a rude state of society, which existed there during certainly two centuries, if not a longer period. The objection of our friend of the local press to our statement as to the burial of Anglo-Saxons lying on the side with the knees bent up, is simply absurd. He seems to think that, in such a case, the Anglo-Saxon may have been "a person of British descent," a pedigree to which we beg civilly to demur; and we should be inclined to ask this rather presumptuous writer on what direct evidence he ventures to assert that this was the peculiar characteristic of "ancient British" interments and of no others. We assert, without hesitation, that the Anglo-Saxon interments at Seamer was made in this manner, and that there was nothing of "ancient British" about it. Under our own eyes, one or two interments in the same form were found in the Anglo-Saxon cemetery at Osengall, in the Isle of Thanet (only one grave, we find on reference to our notes, was opened), which represented the Anglo-Saxons in the highest degree of their social development before their conversion to Christianity. And similar forms of laying out the body for the grave have been found in other Anglo-Saxon interments.

In fact, it was a very common form of interment among the peoples of the Teutonic race, and as he appears to be much in want of sound information, we will only ask this newspaper writer to take the trouble to consult the little book of the brothers Lindenschmidt, *Das Germanische Todtenlager bei Selzen in der Provinz Rheinhessen*, and other German works on the pagan Germanic period, and the works of the Abbé Cochet and others on the Frankish graves, where he will see that the practice of laying the dead in the grave with the knees doubled up, was characteristic of the Germanic tribes before any of them came into this island, and among those who did not come. Possibly with a little study our friend may find that his doubled-up "ancient Britons" derived their peculiar form of interment from their Teutonic forefathers of the fourth and fifth centuries! It has been suggested that the cause of this form of interment was merely that they put the body in a chest or coffin which was too short to allow it to be stretched out at length. Traces of the decayed wood of such chests have been met with.

Excavations made in the KIRKHEAD BONE-CAVE, near Ulverstone in Lancashire, have brought to light a quantity of animal bones, mostly of common and recent animals, a few human bones, or rather fragments of human bones, and some manufactured objects. Among the latter are several small objects in bronze, two beads (one of earthenware, the other of amber), and a piece of pottery, all certainly Roman; an iron knife-blade, either Roman or later, a good example of the bronze implement popularly called a "celt;" and a fragment of one of those rudely-made burial urns which are usually called British. We should judge that the greater portion of these objects were deposited here rather late in the Roman period. They are at present deposited for exhibition at the rooms of the Anthropological Society. A subscription has been commenced for the purpose of carrying on further excavations in this cave, and, from the amount of suscriptions already received, we may hope soon to see this interesting cave thoroughly explored. T. W.

SCIENTIFIC SOCIETIES.

BY W. B. TEGETMEIER.

THE meetings of the learned and scientific societies, during the past month, have not been characterized by the announcement of any very remarkable discoveries, but, nevertheless, some subjects of great interest have been discussed. At the Zoological Society, Professor Owen read a paper on the Osteology of the Dodo—the *Didus ineptus* of Linnæus. The materials on which this paper was founded consisted of a large number of bones, recently discovered in an alluvial deposit at Mahébourg, Mauritius. The communication was of a very elaborate character; the measurements, to fractions of an inch of each bone, being stated. Although these technical details and measurements are most valuable for reference, the object of reading them to a meeting is not evident, as no one can possibly

carry away such a mass of minute details. The description of the general character of the skeleton, and of its relation to the well-known drawings of the animal, was most interesting. Professor Owen, like most other comparative anatomists, now regards the dodo as a bird of the Columbine group, closely related to the *Didunculus*, or little dodo, described in a former volume of the INTELLECTUAL OBSERVER. It was, in fact, a gigantic ground pigeon, destitute of the power of flight. Perhaps the only one of Professor Owen's inferences which will not be generally acquiesced in by naturalists, is his conclusion that the animal might have been a partial flesh-feeder. It is difficult to account for this suggestion, unless it be the remainder of an opinion formerly stoutly maintained by Professor Owen, viz., that the dodo belonged to the Vulturine group.

At the Royal Geographical Society, Mr. Du Chaillu read an account of his unsuccessful attempt to penetrate into the interior of Equatorial Africa. The paper described a journey nearly due east from the coast line, in 1° south latitude, to about 300 miles in the interior, across numerous parallel ranges of mountains. The author described his progress as being impeded by the occurrence of small-pox amongst the native tribes, and stated that he encountered a race of pigmies, four feet four inches to four feet five inches in height, and that they were of a particularly hairy appearance. His further advance was checked, according to his own account, by the accidental discharge of a gun by one of his party. This caused the death of two persons, when his followers were seized with a panic, threw down their arms, and fled. They subsequently, however, maintained a fight from nine A.M. till five P.M., but with what arms did not appear—and eventually regained the coast. After the conclusion of the paper, a discussion followed, in which Mr. Crawford stated that he did not believe in the existence of an unknown race of pigmies near the coast. Mr. Du Chaillu made a short reply, and ten days subsequently wrote a letter to the *Times*, stating that the men did exist, and were characterized by remarkably short hair. The statements of the writer do not seem likely to attract much attention amongst the scientific public beyond the limits of the Royal Geographical Society.

The Friday evening meetings of the Royal Institution commenced on the 19th, when Professor Tyndall gave a lecture on the Radiation and Absorption of Heat, with reference to the Colour of Bodies. The lecture was well illustrated by experiments, but no new discoveries of any importance were announced on the subsequent Friday. Professor Tyndall was followed by Mr. Baker, on the Sources of the Nile; and the lectures for the ensuing month will be: Earl Stanhope, on Arabic Philosophy; A. Smith, Esq., on the Deviation of the Compass in Iron Ships; Col. James, on Jerusalem; and W. Pengelly, Esq., on Kents Cavern, Torquay.

The most attractive meeting of the month was the reception of the President of the Astronomical Society, Warren De La Rue, Esq., at Willis's Rooms. The company comprised the most eminent *savans* now in town, and a large number of the more illustrious patrons of science, and for the first time ladies were present by

special invitation. The rooms were filled with objects of interest and of the highest scientific value. Amongst them was a silvered glass mirror reflecting telescope, made by Mr. Browning for Mr. Slack. The mirror is by Mr. With, of Hereford. It is six and a-half inches in diameter, and has been found, on trial, to be of rare excellence. The equatorial stand devised by Mr. Browning, with the advice of Mr. Slack, is remarkable for the judicious disposition of the weight of the several parts, and for uniting great solidity with elegance of proportion. The circles are twelve inches in diameter, read by a vernier in the same plane with the graduations, and the movements are remarkably smooth. The mirror is mounted in a new form of cell, contrived by Mr. Browning; and instead of a small reflector there is a beautifully-worked prism, supported, on Mr. Browning's plan, by three strips of chronometer spring—an arrangement that gets rid of some disagreeable effects which the ordinary single arm of considerable thickness produces, when large stars are in view. The eye-piece and prism revolve, so as to accommodate the eye in any position in which the telescope can be placed.

Messrs. Powell and Lealand exhibited their new illuminators for opaque objects under high powers. Messrs. Smith and Beck showed theirs, and also a very fine eighth, with a prism brought near the objective, so as to give a beautiful effect with a binocular microscope. Messrs. Horne and Thornthwaite showed one of the new and clever miniature set of vacuum tubes, with electric discharges from a very small but powerful coil-machine. The effects, though on a small scale, were as brilliant as when a large and costly apparatus is employed. Mr. Ross had a handsome display of microscopes. Messrs. Cooke exhibited a magnificent-looking achromatic object-glass, twenty-five inches in diameter, and nearly finished. If, as it is to be hoped, this objective is finished with the customary perfection of Messrs. Cooke's work, it will be the finest thing of its kind yet done. Up to the present no defect appears in the glass; and Messrs. Cooke's method of grinding and polishing is admitted on all hands to be admirably devised for the purposes of accuracy and high finish.

NOTES AND MEMORANDA.

The Fever Plant.—In Dr. Livingstone's *Narrative of an Expedition to the Zambesi*, he speaks of a caution given by the natives against a plant which excites fever, and he adds, "Dr. Kirk discovered it to be the *Pædevia fœtida*, which, when smelt, actually does give headache and fever. It has a nasty fetor, as its name indicates." The *quantity* of matter thus producing disease must be wonderfully small.

Spectra of Comet 1, 1866.—The comet so named was discovered by Tempel, at Marseilles, on the 19th December, at 8 p.m., near β Ursæ minor. He described it in *Astronomische Nachrichten* as a round nebulous object, somewhat thickened in the middle with a breadth of 12′. At times it seemed as if it "pulsated" forth a tail about ½° in length. He could not detect a decided nucleus. It moved so rapidly that by 1 o'clock it was under ζ Ursæ Minor. On 23rd December, Professor Bruhns, of Leipsig, found it in Cepheus, and he pronounced it to be a faint nebulous mass. Dr. Oppolzer, at Vienna, saw it as a faint nebulous mass,

with an eccentric and very faint nucleus. This delicate object has afforded spectra to Mr. Huggins with his 8-inch telescope. He saw it as an oval nebulous mass, with a minute stellar nucleus. The light from the coma gave a continuous spectrum. The nucleus gave a spectrum in which the nitrogen characteristics were apparent. Mr. Huggins thinks the nucleus a self-luminous body, and that the coma probably shines by reflecting solar light. It was, however, too faint to enable him to recognise the solar lines. Dr. Oppolzer states that this comet will be scarcely visible in February. On the 1st February he gives its place as R.A. 23h. 43m. 38s., S.D., 1° 50′ 4″.

New Planet (86).—Dr. Tietjen, of Berlin, discovered a new planet on the 4th January, while looking for planet 85. Its magnitude is 11·9. Planet 85, R.A. 1h. 11m. 24s. ·59; N.D. 3° 17′ 28″ ·3. Planet 86, R.A. 1h. 11m. 8s. ·68; N.D., 3° 23′ 47″.

Newly Recognized Force disturbing the Moon.—M. Delaunay has in *Comptes Rendus*, No. 24, 1865, an elaborate paper on this subject. His conclusion is that the "perturbing forces to which are due the periodical oscillations" of the surface of the sea (the tides) in "exerting a heaping-up effect in the water, determine a progressive retardation in terrestrial rotation, and produce also an apparent sensible acceleration in the mean movement of the moon."

Biela's Comet.—*Comptes Rendus* contains a telegram from Secchi to Le Verrier. "Rome, 10th December, 1865.—Yesterday morning, at 9h. 6m., Biela's comet very faint. R.A. 22h. 46m. 37s. Polar distance, 94° 8′."

Spontaneous Generation Experiments.—M. Victor Meunier, controverting M. Pasteur's statements that organisms do not appear in boiled infusions when the necks of the vessels are curved so as to prevent access of germs, recites some of his own experiments, which he says show that "neither mannite associated with ammoniacal salts, nor pure mannite, nor ox-bile, give living organisms, and that of three vessels containing beef soup two were peopled with animalcules and the other remained sterile. Three other vessels containing urine gave two with animalcules and one with protophytes." M. Pasteur affirms that by having a multiplicity of apertures, M. Meunier has enabled external germs to get in.

Purifying Water for Fish Hatching.—Dr. W. H. Ransom states in *Transactions of the Midland Scientific Association*, that a few drops of a weak solution of permanganate of lime, added night and morning, sweetens water and supplies oxygen, and thus diminishes the mortality in fish-hatching.

A Fossil Lizard in Copal.—The *Annals of Natural History* for January, contain an account translated from *Monatsbericht de Preuss. Akad.*, for August, 1865, of a piece of fossil copal from Zanzibar, containing an impression of a fossil lizard, so perfect that all the parts of the body and the scales were distinct. It was recognized as belonging to the genus *Hemidactylus*.

Muscular Power of Insects.—M. Felix Plateau has made fresh experiments on the muscular force exerted by insects. By attaching a wire to the legs of insects he ascertains the weight they draw on a given surface, and finds that a beetle, *Donacia nymphea*, can pull 42·7 of its own weight. If a horse were equally powerful he would be able to draw 25,000 kilogrammes, or more than double that number of pounds.